

# New Scientist

WEEKLY 27 August 2022

## PREDICTING A LIFETIME

Should you sequence your baby's genome?

## DOUBLE IMPACT

Dinosaurs may have been hit by second asteroid

## PROTON CHARM

Unexpected quark found in familiar particle

## THE INNER LIVES *of* PLANTS

Radical new claims of consciousness in the botanical kingdom



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## NS Live

### Calling all schoolchildren

For the first time in London, New Scientist Live has a dedicated day just for schools. We have a packed programme of engaging talks and an arena full of interactive demonstrations that will inspire young minds and bring science to life. Visit with your class at the ExCeL Centre in London on 7 October.

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## Podcast

### Weekly

In this episode, the team find out how physicists plan to use laser beams to build an artificial neural network. They also look at the dangers of radiation on the journey to Mars and chat with BAFTA-winning sound recordist Chris Watson, who shares his gorgeous soundscapes from three threatened ecosystems, including the Vatnajökull glacier in Iceland and the Namib desert in southern Africa. There is some talk of monkey sex toys, too. Don't ask.

[newscientist.com/nspod](https://www.newscientist.com/nspod)

## Podcast



SHUTTERSTOCK/ZARUBA ONDREJ

**Listen up** What does the Namib desert in Africa sound like?

## Video



JOERG MITTER/RED BULL CONTENT POOL

**Quietly does it** The World Rallycross Championship goes all-electric

## Video

### Electric race cars

Join *New Scientist* as we go trackside in Stjørdal, Norway, at the FIA World Rallycross Championship, a mixed-surface racing series that has gone all-electric this year. The new sound may take some getting used to, but the speed of these cars is still extremely impressive – they have the potential to be the quickest rallycross vehicles ever built.

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## Newsletter

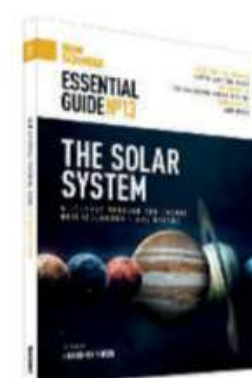
### Wild Wild Life

On the back of record-breaking summer weather across the UK, news and digital director Penny Sarchet investigates drought-resistant plants and the features that allow them to survive in hot, dry conditions. She also has news of a leggy fish that gave up on adapting for life on land and returned to the water instead.

[newscientist.com/wildwildlife](https://www.newscientist.com/wildwildlife)

## Podcast

**“Horses, lions, walruses, birds, even porcupines all masturbate”**



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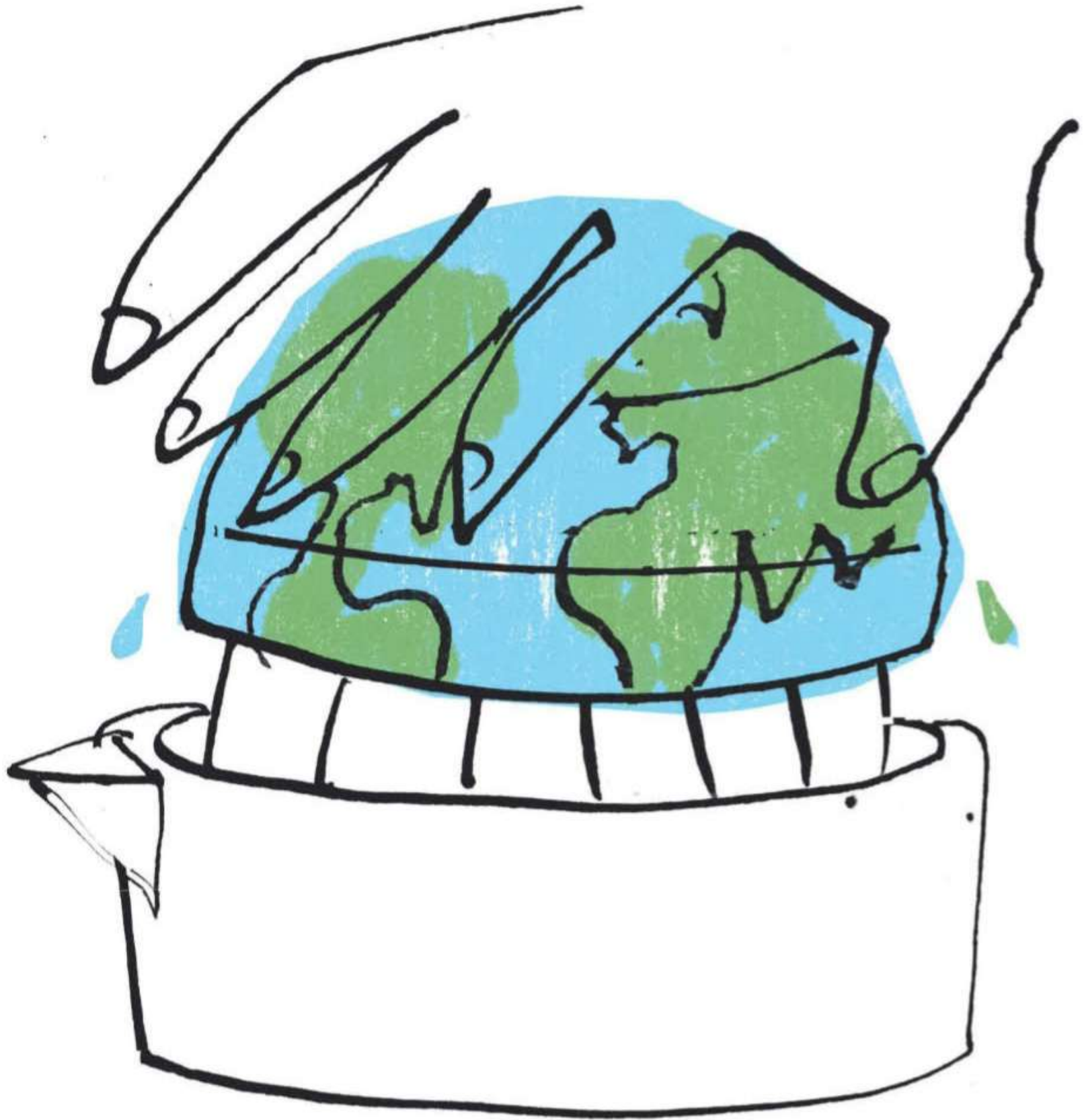


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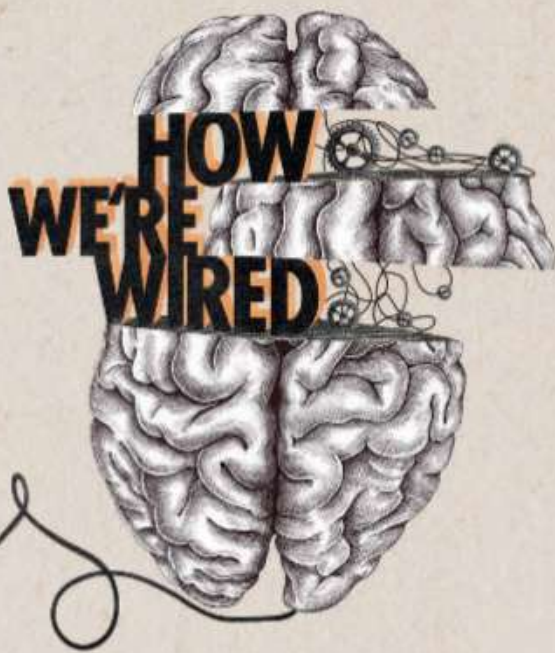


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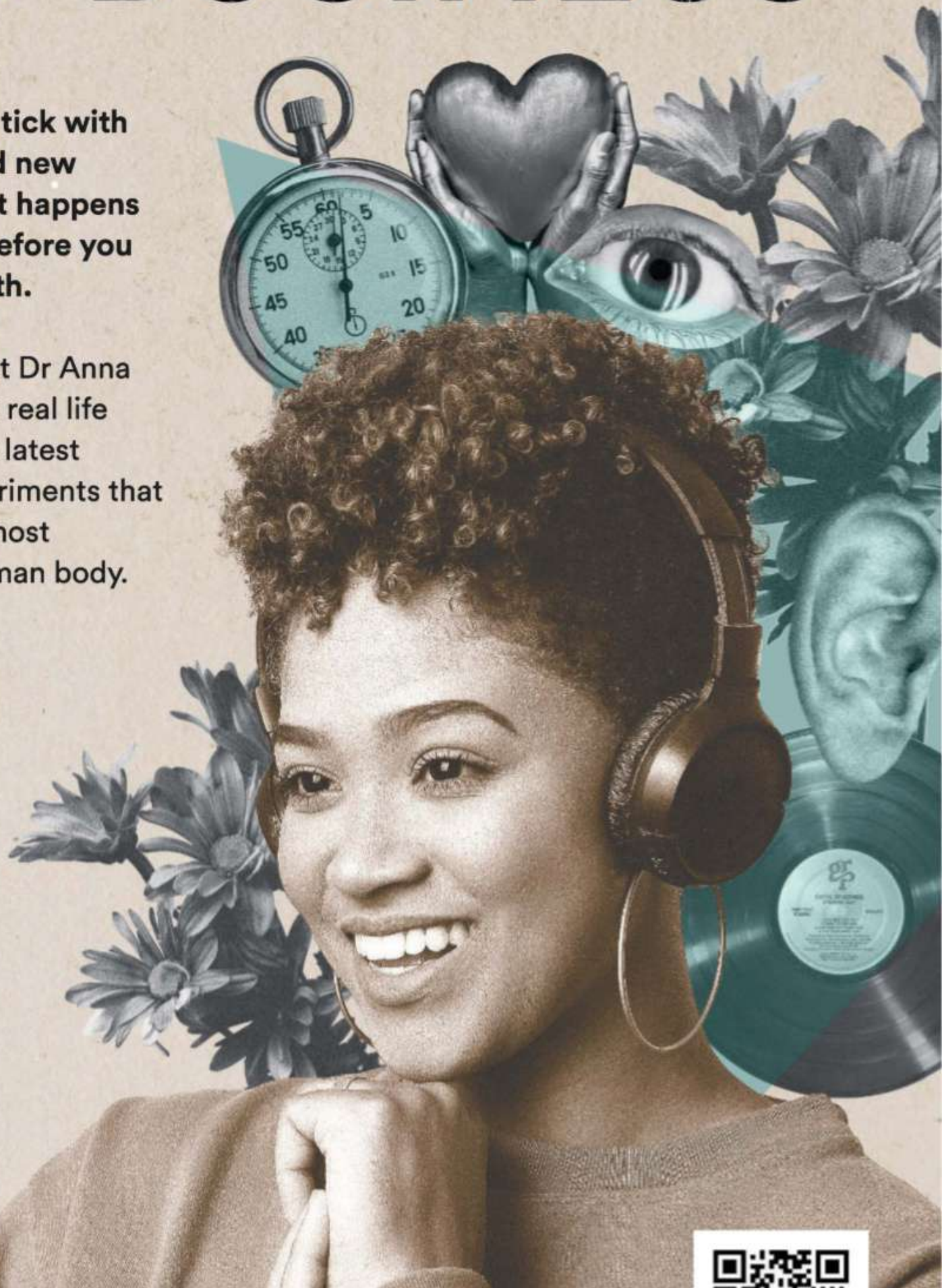
# OWN YOUR MIND BUSINESS

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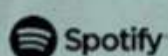
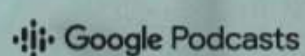
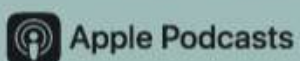
Presented by anthropologist Dr Anna Machin, this series features real life stories, expert analysis, the latest research and at-home experiments that will open your eyes to the most fascinating organ in the human body.



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Search for 'How We're Wired' and subscribe wherever you get your podcasts.



# Going wild

Plant consciousness might be an uncomfortable concept, but it is worth exploring

TAKE a look at that plant sitting on the windowsill or tree in the local park. What might it be feeling? Could it be thinking? Experiments are probing the idea of plant cognition, even going so far as to suggest they possess some form of consciousness.

As wild as it sounds, it isn't a new idea. The field of "plant neurobiology" began in 2006, aimed at understanding how plants process information from their environment.

It is now clear that plants are capable of complex communication and can intricately sense their surroundings, ideas that were originally dismissed. But proponents of plant consciousness take things further and draw parallels between the electrical signalling that can be found from root to stem with that

present in the nervous system of animals. They claim to show that plants are capable of intentionally choosing to perform certain behaviours, of learning and perhaps even having personalities, as we report on page 38. If plants are experiencing a sentient inner world,

**"Extending cognition to plants would mean a seismic shift in our view of humanity"**

they argue, it becomes imperative that we find ways to test and understand it.

Extending the concept of cognition to plants would mean a seismic shift in our view of the uniqueness of humanity, not to mention how we treat our botanical friends, so the bar of acceptance is high.

Researchers rising to the challenge are hoping to probe plants with tools usually reserved for the human brain.

The research can appear persuasive, but it is in its infancy and suffers from replication failure. Critics say the field is highly speculative; that the behaviours can be explained through innate reflexes.

Whether we decide that plants have cognition may come down to our ability to describe consciousness itself – something we are far from doing. But rather than dismiss the idea, we should welcome the chance to devise new ways to test our understanding of consciousness. It might just improve our grasp of the human mind. At the very least, our trees and houseplants should benefit from the extra attention – consciously or not. ■

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## Nearest and dearest

Our close friends activate distinct areas of the brain **p9**

## OK computer

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## Covid transmission

Most people are still infectious after five days **p13**

## Speedy rover

Software update will let Curiosity go 50 per cent faster **p15**

## Tree of life

Creature with no anus wasn't our ancestor **p19**



HE PENGLE/CHINA NEWS SERVICE VIA GETTY IMAGES

## The bed of the Jialing river is exposed in Chongqing, China

local water supplies have run out and drinking water has had to be trucked in. On 19 August, China announced a national drought alert for the first time in nine years.

Hydroelectricity generation has fallen because of the low water levels. Sichuan has been especially affected because it normally gets 80 per cent of its electricity from hydropower. Thousands of factories in the province have had to cease operations because of electricity shortages amid high demand for air conditioning. Offices and shopping malls were also told to reduce lighting and air conditioning to save power.

In Sichuan alone, 47,000 hectares of crops are reported to have been lost and another 433,000 hectares damaged. The agriculture ministry has said it will try to increase rainfall by seeding clouds. It remains scientifically unclear whether cloud seeding makes a significant difference.

China is far from the only place affected by drought. Europe is having what may be its worst drought in 500 years. There is also a drought in the Horn of Africa, and across much of the US and Mexico.

Lower crop yields in these regions could worsen the global food crisis. Global food prices hit record levels even before Russia invaded Ukraine, and though they have fallen since March, they remain higher than in previous years. However, China has built up large grain reserves in recent years, so it can make up for some shortfall.

According to a 2021 report from the Intergovernmental Panel on Climate Change, droughts have been increasing as a result of global warming and will become more frequent and severe as the planet continues to warm. ■

## Extreme weather

# China's worst heatwave

A long spell of extreme hot and dry weather is affecting energy, water supplies and food production, reports **Michael Le Page**

LOW rainfall and record-breaking heat across much of China are having widespread impacts on people, industry and farming. River and reservoir levels have fallen, factories have shut because of electricity shortages and huge areas of crops have been damaged. The situation could have worldwide repercussions, causing further disruption to supply chains and exacerbating the global food crisis.

People in large parts of China have been experiencing two months of extreme heat. Hundreds of places have reported temperatures of more than 40°C (104°F), and many records have been broken. Subway stations have set up rest areas where

people can recover from the heat.

On 18 August, the temperature in Chongqing in Sichuan province reached 45°C (113°F), the highest ever recorded in China outside the desert-dominated region of Xinjiang. On 20 August, the temperature in the city didn't fall below 34.9°C (94.8°F), the highest minimum temperature ever recorded in China in August. The maximum temperature was 43.7°C (110.7°F).

It is the longest and hottest heatwave in China since national records began in 1961. According to weather historian Maximiliano Herrera, who monitors extreme temperatures around the world, it is the most severe heatwave recorded anywhere.

"This combines the most extreme intensity with the most extreme length with an incredibly huge area all at the same time," he says. "There is nothing in world climatic history which is even minimally comparable to what is happening in China."

**"There is nothing in world climatic history which is comparable to what is happening in China"**

Together with the extreme heat, low rainfall in parts of China has led to rivers falling to low levels, with 66 drying up completely. In parts of the Yangtze, water levels are the lowest since records began in 1865. In a few places,

## Geology

# A way to predict earthquakes before they happen

Alex Wilkins

WE MIGHT be able to predict big earthquakes in the near future better than we thought, according to research that used machine learning to analyse decades of past earthquakes in California.

There have been many attempts to predict earthquakes using real-world signals, such as changing water levels, or data catalogues, such as the time intervals between earthquakes, but there has been no consistently reliable method.

One leading seismological hypothesis, first proposed in the 1970s, was that predictability based on data catalogues wasn't possible because the information was random and so didn't contain useful details about future earthquakes.

Now, John Rundle at the University of California, Davis, and his colleagues have developed an algorithm that gives the probability of an earthquake of magnitude 6.75 or greater happening at various times over a three-year period, in a region of California that covers 10 degrees of latitude and 10 degrees of longitude

(just under 1000 square kilometres). The model is based on records of earthquakes since 1970 and shows that past earthquake data isn't random as previously thought, says Rundle.

Rather than look at the interval between earthquakes, as previous studies have, the team examined the number of earthquakes per unit of time and then used a machine learning model to look for patterns in the data.

## 0.708

**Model's skill level (out of 1) at predicting earthquakes**

The group then applied statistical techniques that are common in economics, such as an exponential moving average, which gives recent events more significance than older ones.

The model gives "nowcasts", which are weather forecast-like probabilities of earthquakes happening in a short, upcoming period of time, such as a 90 per cent chance of a major earthquake within three years.

The chance of a greater-than-

magnitude-6.75 earthquake happening in the region varied over the three years from about 35 per cent to as much as 100 per cent. Although the team doesn't give specific times for an earthquake, there is a kink in the hockey stick-shaped pattern of risk that the model produces as the chance of an earthquake rises over time, where the probability quickly tends to certainty. Rundle suggests that this kink is where people should start worrying. Not long after an earthquake, the risk drops again.

The team tested the algorithm's "skill" against the California data, rating it as 0.708 – perfect skill at predicting earthquakes was rated as 1, no skill as 0.5 and always being wrong as 0 ([arxiv.org/abs/2208.03839](https://arxiv.org/abs/2208.03839)).

The pattern of predictability also validates the hotly debated idea of there being regional earthquake cycles. "That sort of cycle has always been elusive," says Rundle. "But what we've done is show that you can see a regional cycle of activity."

He is keen to try the model on other data sets, such as those from Japan, before seeing if it can be used to mitigate the impact of future earthquakes.

Some people aren't as convinced that this method will offer particular advances. "Earthquakes are not numbers; earthquakes are real things," says Roger Musson at the British Geological Survey. "They have physical properties and they have physical dimensions, and numbers are, at best, only a very approximate representation of the seismological reality." ■

**A 6.7-magnitude quake in 1994 collapsed freeways in California**

## Mathematics

# First demonstration of tricky final Rubik's cube sequence

Jeremy Hsu

A RUBIK'S cube solver has become the first person to show proof that they had successfully combined the final two steps of solving the mechanical puzzle into one move. The feat required memorising thousands of possible sequences for the final step.

Most skilled speedcubers – people who compete to solve Rubik's cubes with the most speed and efficiency – choose to solve the final layer of the cube with two separate moves that involve 57 possible sequences for the penultimate step and 21 possible sequences for the final one.

Combining those two separate actions into a single step requires a person to memorise 3915 possible sequences. These sequences were previously known to be possible, but nobody was reported to have successfully achieved this so-called Full 1 Look Last Layer (Full 1LLL) move until a speedcuber known by the online username "edmarter" shared a YouTube video demonstrating the accomplishment.

Over the course of about a year, he spent 10 hours each weekend and any free time during the week practising and memorising the necessary sequences, he told *New Scientist*. That often involved memorising 144-movement sequences in a single day.

All that effort paid off on 4 August when he uploaded a video demonstrating the Full 1LLL over the course of 100 separate puzzle solves. He also posted his accomplishment to Reddit's r/Cubers community, where the top-voted comment simply said: "This is absolutely insane."

His average solve time for each Rubik's cube over the course of that video demonstration run was 14.79 seconds. He says he had an average solve time as low as 12.50 seconds during two practice runs before recording the video. ■



DENIS POROY/AFP VIA GETTY IMAGES

## Astronomy

# Peering into a strange galaxy

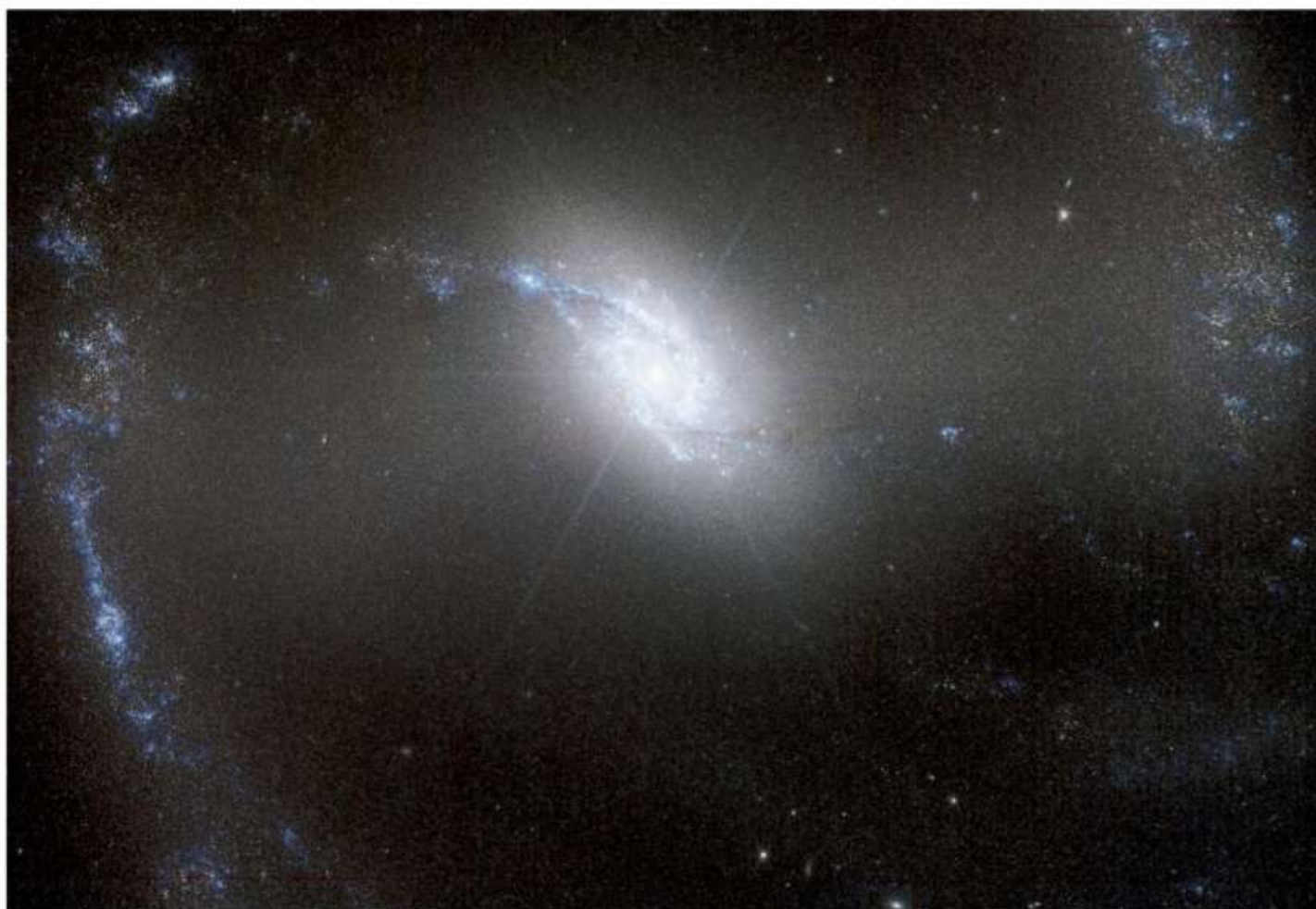
The Great Barred Spiral Galaxy has spectacular regions of star formation

Leah Crane

THE James Webb Space Telescope (JWST) has taken an extraordinary picture of a strange galaxy, called NGC 1365 or the Great Barred Spiral Galaxy. It has one of the highest star formation rates of any galaxy we have ever seen, driven by the bar of stars at its centre that connects its two spiral arms together.

"To make stars, you have to collapse gas together," says Brad Whitmore at the Space Telescope Science Institute in Maryland. "In NGC 1365, the bar acts like a conveyor belt, sending gas right into the heart of the galaxy where it's as concentrated as can be."

JWST uses infrared wavelengths, which let it peer through the galaxy's dust. This allowed researchers to spot a feature in NGC 1365 that they knew ought to be there, but was tough to see before: a small ring around the centre of the galaxy where the most intense star formation takes place. ■



NASA/ESA/CSA/STScI/R. COLOMBARI

## Neuroscience

# Distinct brain areas light up for close friends

WE MAY think about our closest friends and family using different parts of the brain than we do for the rest of our social circle.

Previous research by Robin Dunbar at the University of Oxford suggests that we have several tiers of friendship and that we spend most of our time and effort on those in our most intimate circle, which consists of around five people

To see if these various layers of friendship are processed differently in the brain, Moshe Roseman at the Hebrew University of Jerusalem and his colleagues asked 26 people to group their friends and family into five categories based on

how close they felt to each person.

The researchers then put the volunteers in a functional magnetic resonance imaging (fMRI) scanner. Inside, they were given the names of two friends and asked to judge which one they were closer to. The questions only ever involved people who the participants had listed in the same closeness category. Each person made 400 comparisons.

When they contemplated people in their most intimate group, the temporoparietal junction, middle temporal gyrus and dorsomedial prefrontal cortex were preferentially activated in the participants' brains. These regions have been implicated

in processing one's own mental state and the mental state of others, says Dunbar, who is also a co-author of the study.

Questions about other friends led to more activity in the medial temporal lobe, retrosplenial cortex and ventromedial prefrontal cortex, which are all involved in memory processing (bioRxiv, doi.org/h8xv).

This may reflect the fact that people said they based their judgements of their wider pool of friends more explicitly on

**"One interpretation is that we use our own mental models of thoughts for people similar to us"**

memories of when they last interacted with that person, whereas judgements for each participant's core group were more based on "gut feelings", says study co-author Shahar Arzy, also at the Hebrew University of Jerusalem.

"One interpretation is that we use our own mental models of feelings or thoughts for people similar to us, as we assume they will be thinking, behaving and feeling in similar ways to us, while we use different models – and different brain regions – to think about people dissimilar to us," says Iroise Dumontheil at Birkbeck, University of London. ■  
Jason Arunn Murugesu

# HowTheLightGetsIn

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## Quantum computers

# Shine comes off the promise of quantum chemistry

Alex Wilkins

QUANTUM computers may not be able to simulate molecules and solve other problems in chemistry as fast as hoped, a new analysis has found.

The promise of quantum computers is that they could solve some tasks exponentially faster than ordinary computers, but this hasn't yet been demonstrated for useful, real-world problems.

One highly anticipated application is calculating the energy levels of molecules, an important task in chemistry. But Garnet Chan at the California Institute of Technology and his colleagues, including researchers at Google and Amazon, have now examined whether quantum computers really could deliver an exponential advantage, and found that the evidence is lacking.

## Reality check

The team calculated how long it would take for classical and quantum methods to find the quantum states of iron-sulphur groups, which are molecules found throughout nature and frequent targets for quantum chemistry.

A common approach to find a molecule's quantum state is to start with a guess and to then fine-tune this until a solution is reached. But Chan and his team found that just determining the initial guess could require so much computing power that the exponential advantage from quantum computing becomes diminished.

They also found that, when compared with quantum methods, there was no indication that classical methods couldn't be optimised

or tweaked to remove the exponential advantage (arxiv.org/abs/2208.02199).

"It's bringing a dose of reality into some of the hyperbole that has gone around this particular question," says David Tew at the University of Oxford. "It's good to do that because it's really important to know where we stand scientifically and what we need to do to make progress."

**"It's bringing a dose of reality into some of the hyperbole that has gone around this question"**

Though Chan and his team examined the evidence for exponential speed-up, they left open the possibility of a smaller improvement in quantum computing called polynomial speed-up, which could still offer a large advantage over traditional methods. They also acknowledged that quantum computing is still at an early stage, with the potential for new technologies to emerge.

"Even if the benefit isn't exponential, if it's a significant polynomial benefit, then it can

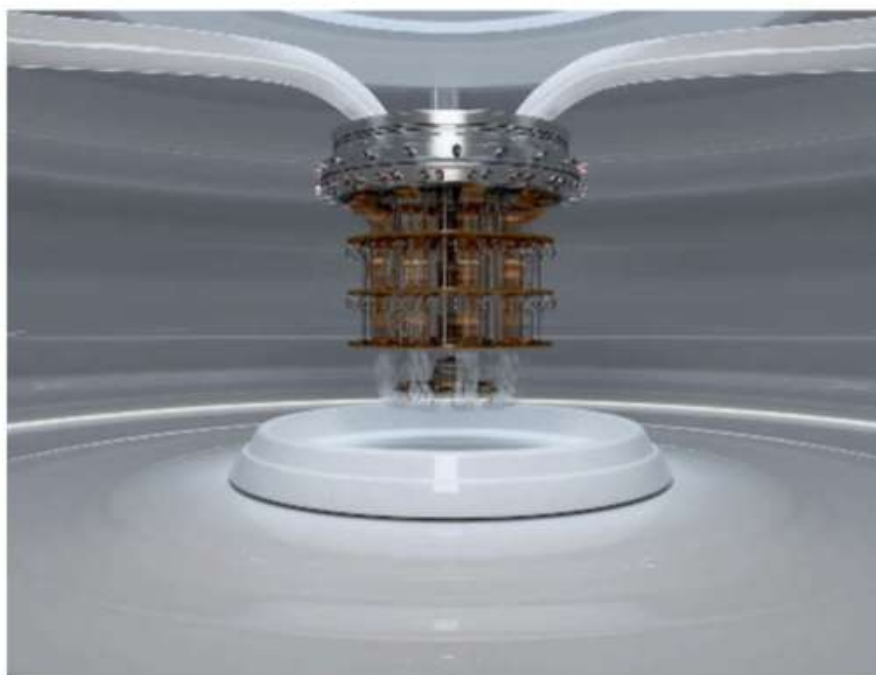
be massively worthwhile," says Tew.

While the work shows that commonly used quantum algorithms might not provide an exponential speed-up, there is a possibility that specific systems and future algorithms might do so.

"It's very hard to be exhaustive when it comes to the full range of chemical systems that can be simulated with classical methods," says Andrew Kerridge "at Lancaster University, UK. "So there's potentially areas that they haven't considered where quantum computing would offer this exponential advantage."

Because there are still large advantages for quantum computers in solving chemistry problems, the results are unlikely to change or halt any current quantum computing research, says Tew. "Hopefully, it will bring more clarity in the way that questions are being asked and answered." ■

**A 3D-rendered illustration of a quantum computer**



BARTLOMIEJ K. WROBLEWSKI/SHUTTERSTOCK

## Solar system

# It may snow upwards in the oceans of icy moons

Leah Crane

**BENEATH** the frozen shell of Europa, flakes of ice may float up through its ocean like strange underwater snow. This process could make the underside of the shell a favourable environment for alien life.

On Earth, the ice shelves in Antarctica are the closest analogue to the ice shells of Jupiter's moon Europa and Saturn's moon Enceladus, which are both thought to host global oceans. There are two types of ice in the Antarctic shelves: congelation ice, which starts in one spot and then spreads out as water freezes onto its edges, and frazil ice, which forms when supercooled water turns into ice crystals that float up to settle beneath the shelf.

Natalie Wolfenbarger at the University of Texas at Austin and her team compared measurements of Antarctic ice with observations and models of the ice on Enceladus and Europa. They found that frazil ice could be common on both worlds, especially in areas where the ice shell is fractured, such as Enceladus's famous "tiger stripes" (*Astrobiology*, doi.org/gqnpjg).

Both frazil and congelation ice are generally less salty than the ocean water from which they form, but frazil ice tends to be particularly pure at around 0.1 per cent of the salinity of the underlying water. The salinity is crucial for the possibility of microbial life there, because organisms may not be able to survive if the water is too salty.

The possible presence of frazil ice is intriguing because it is porous and could bring nutrients from deep underwater up to the bottom of the ice. "At the bottom of the ice shelf it could be pretty mushy, and that's an environment that organisms like to inhabit," says Wolfenbarger. "We have actually seen protists in these environments on Earth, which hints that these might be good environments to look for life – assuming we can get to them." ■

Neurology

# Covid-19 linked to brain conditions

The risk of being diagnosed with some neurological conditions after having covid-19 may be higher than for other respiratory infections, reports **Jason Arunn Murugesu**

PEOPLE who have had covid-19 have a higher risk of being diagnosed with some neurological conditions up to two years later compared with those who experienced other respiratory infections, such as seasonal influenza.

Paul Harrison at the University of Oxford and his colleagues analysed the medical records of more than 1.25 million people from around the world who were diagnosed with covid-19 between 20 January 2020 and 13 April 2022.

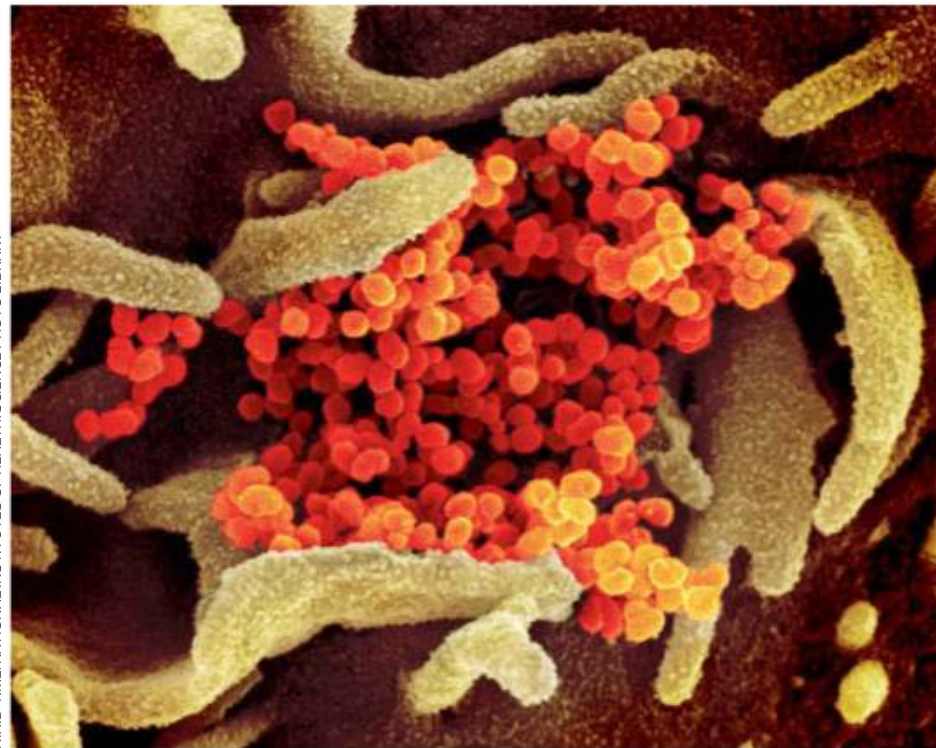
The researchers compared the participants with people who experienced other respiratory infections in this period. In this control group, the researchers only included people who hadn't tested positive for the coronavirus at any point in the time frame.

For both sets of participants, the team analysed the risk of developing 14 neurological and mental health conditions in the two years post-infection for three age groups: children under 18, adults aged 18 to 64 and adults older than 65.

Previous studies have examined neurological and mental health symptoms in the six months following covid-19, but this is the first large-scale study to look for these effects up to two years post-infection, according to the researchers.

"This is very important because for patients, clinicians and public health authorities... you want to know at what point after covid-19 can you be reassured that you're no longer at increased risk of getting a psychiatric diagnosis," says Harrison.

Among adults aged 18 to 64, the risk of a first-time diagnosis of depression or anxiety in the two months after being infected with the coronavirus was 75 per cent and 60 per cent higher,



NIH/D-RML/NATIONAL INSTITUTES OF HEALTH/SCIENCE PHOTO LIBRARY

**SARS-CoV-2 virus particles emerging from cells grown in the lab**

**2.6%**  
Children under 18 who developed epilepsy or seizures within two years of having covid-19

**6.4%**  
Adults aged 18 to 64 diagnosed with brain fog within two years of having covid-19

**4.5%**  
Adults aged over 65 diagnosed with dementia within two years of having covid-19

respectively, than seen with other respiratory infections.

However, these differences were short-lived. Over two years, 18.2 per cent of those infected with the coronavirus and 18.8 per cent of those infected with other respiratory diseases were diagnosed with depression. In the same period, 11.6 per cent of those with covid-19 and 11.5 per cent of those infected with other respiratory diseases were diagnosed with anxiety disorders.

The risk of being diagnosed with brain fog in adults aged between 18 and 64 remained higher in people who had covid-19 for up to two years post-infection, compared with those who experienced other respiratory infections.

In this age group, 6.4 per cent were diagnosed with brain fog within two years of covid-19, compared with 5.5 per cent of the participants who experienced other respiratory infections. A statistical analysis suggests this is a significant difference.

The risk of dementia was elevated in those aged over 65 for

up to two years following covid-19, with 4.5 per cent diagnosed with dementia in the two years after covid-19, compared with 3.3 per cent in the control group.

Children weren't found to have a higher risk of developing anxiety or depression after covid-19, compared with those who experienced other respiratory infections. However, they did face a higher risk of epilepsy or seizures for up to two years post-infection, compared with those who experienced other respiratory infections. The analysis found that 2.6 per cent of children infected with the coronavirus developed epilepsy or seizures within two years after infection, compared with 1.3 per cent for other respiratory infections (*The Lancet Psychiatry*, doi.org/h8vm).

## Several explanations

Why covid-19 raises the risk of different neurological or mental health conditions is unclear, but there are several possible explanations, says Harrison. The virus could persist in certain cells in the nervous system, or the immune system's efforts against the coronavirus may result in some collateral brain damage, he says.

Aravinthan Varatharaj at the University of Southampton in the UK says these findings may reflect the fact that people with a higher risk of neurological conditions may be more likely to get covid-19 in the first place, but it could also reflect the impact of the coronavirus on the brain.

"Infections such as covid may affect the brain through a number of mechanisms, including signalling through the vagus nerve, activation of the immune system and changes in the blood-brain barrier," he says. ■

## Virology

# Most people with covid-19 are still infectious after five days...

Clare Wilson

TWO-THIRDS of people with covid-19 are still infectious five days after their symptoms begin, according to the most comprehensive study yet of people catching the coronavirus.

The research also found that lateral flow tests – also called rapid antigen tests – give incorrect negative results about a third of the time when people are in the first days of developing covid-19, although they are much more accurate for detecting when people stop being infectious at the end of their illness.

Seran Hakki at Imperial College London and her colleagues studied people before, during and after they developed covid-19 between September 2020 and October 2021. They did this by asking those who had been in close contact with known cases to carry out frequent nasal and throat swabs and keep daily symptom diaries.

The swabs were tested by PCR and lateral flow devices, and any PCR-positive samples were subjected to a further assay that calculated how much infectious

virus was in the mucus – the person's "viral load", which is seen as a key measure of infectiousness. This was done by incubating different dilutions of the mucus in a dish with cells vulnerable to infection.

Of more than 700 contacts of cases, 42 people had the beginning and end of their infectious period revealed by the tests. About one in five of these people were found

**Lateral flow tests are less reliable in the early stages of an infection**

to be infectious before any symptoms began. Lateral flow tests gave an accurate positive result 67 per cent of the time early on in the illness.

Towards the end of people's illness, two-thirds were still infectious five days after their symptoms began, although they did have lower levels of infectious virus in their nasal and throat mucus. A quarter were still infectious after seven days. In later stages of the illness, as people's viral loads fell, lateral flow tests correctly gave positive results

for 92 per cent of people who were infectious (*The Lancet Respiratory Medicine*, doi.org/h8n6).

Advice in many countries, including the UK, is that most people can stop self-isolating after five days, although they should avoid meeting people who are more vulnerable to covid-19 for 10 days. Those under 18 are advised to self-isolate for only three days in England and Scotland.

"This shows beyond a shadow of a doubt that people are releasing infectious virus for far longer than is stated on current guidance," says Stephen Griffin, a virologist at the University of Leeds in the UK, who wasn't involved in the study.

However, the results may be slightly different for the BA.5 omicron subvariant that is currently prevalent, says Hakki.

Susan Hopkins at the UK Health Security Agency says the guidance remains under review. "We know that most transmission in adults occurs three days before the onset of symptoms to five days after, and the infectiousness for omicron peaks within a shorter time frame than previous variants," she says. ■



SHUTTERSTOCK/JINK DROP

## Pathology

### ... while many with omicron don't know they are infected

MORE than half of people infected with the omicron variant of the coronavirus may be unaware they are carrying the virus, raising the risk they could inadvertently spread the infection.

"Having most people with covid-19 being unaware of their infection status, especially while actively transmissible, makes it likely a major driver of the ongoing pandemic," says Susan Cheng at

the Cedars-Sinai Medical Center in California.

Cheng and her colleagues took blood samples from 2479 people who worked at or were registered at a medical centre in Los Angeles. At least two samples were taken per participant. The samples were taken between 15 December 2021 and 4 May 2022, during which time omicron became the dominant variant and several subvariants, such as BA.4 and BA.5, emerged.

Of the participants, 210 were found to have had covid-19 between the first time their blood was taken and subsequent samples,

based on levels of coronavirus-specific antibodies in their blood.

To ensure this antibody response wasn't induced via vaccination, the researchers specifically looked at the participants' IgG-N levels. IgG-N is an antibody to a structural protein on the SARS-CoV-2 coronavirus that becomes elevated when someone is naturally exposed to the virus, but stays low post-vaccination.

Out of the 210 participants

**"Ten per cent experienced mild symptoms but attributed them to other infections"**

who showed evidence of a recent infection, 56 per cent were unaware they had been infected. Ten per cent of this group said they had experienced mild symptoms but attributed them to other infections, such as the common cold (*JAMA Network Open*, doi.org/gqnckm).

Cheng says the findings highlight the importance of each individual self-testing and taking precautions, even if they think they aren't infected. "These are actions that everyone can be empowered to take on and can make a difference in curbing spread of the virus." ■

Carissa Wong

## Health

# Abortion fight flares up in the UK

Doctors in the UK say that attempts to restrict access to abortion services are an unacceptable barrier to healthcare, reports **Jason Arunn Murugesu**

ANTI-ABORTION groups in the UK are becoming increasingly vocal and making it more difficult for people to access healthcare, doctors and health bodies say.

Besides the notable exception of Northern Ireland, where abortion was only permitted in very restricted circumstances until 2019, the issue is relatively uncontroversial in the UK. About 90 per cent of adults in the country believe that women should be able to access abortion services, according to a YouGov poll in 2020.

Fifty-five per cent of adults in the US say abortion should be legal in all or most cases, according to a poll conducted shortly before the US Supreme Court repealed *Roe v Wade*, the 1973 ruling that protected the right to abortion. The repeal has been celebrated by anti-abortion groups throughout the US.

Despite low levels of support, anti-abortion groups do exist in the UK. Several continue to make their presence known outside abortion clinics throughout the country and to lobby policy-makers. In 2019, more than 100,000 people sought abortions at clinics that were targeted by protesters, according to the latest figures from the British Pregnancy Advisory Service.

"The overall numbers [of anti-abortion activists] are not increasing, but what pro-life groups have been able to do is increase mobilisation of the very small number of people who are against abortion," says Pam Lowe at Aston University in Birmingham, UK, who has studied many of these groups. "There's certainly been an increase of activities outside clinics over the last decade or so."

Audrey Brown, a gynaecologist in Glasgow, UK, says there was one day in late March where about 100 people stood right outside



MARK KERRISON/IN PICTURES VIA GETTY IMAGES

her hospital and held up placards with pictures of fetuses on them.

"It's the same building that people go to have babies, or who have a miscarriage, or have a stillborn baby," she says. "And for people who want an abortion, it visibly affects some of my patients."

"We've certainly had people very shaken and tearful because of what they've had to pass by,"

**"We've had people very shaken and tearful because of what they've had to pass by"**

she says. "They've got a right to healthcare if they need it." Brown says her team has started telling patients to take different entrances into the hospital when they know protesters are going to be outside.

"The ongoing harassment and intimidation of both women and staff outside of clinics is unacceptable, and would not be tolerated for any other healthcare service," says Jonathan Lord at the

Royal College of Obstetricians and Gynaecologists. "We have seen anti-abortion movements [in the UK] emboldened by the overturning of *Roe v Wade*, and there has been a rise of anti-choice sentiment across social media."

It is too early to say if this has translated to an increase in activity outside UK abortion clinics, says Lord. But Brown says this year has been the worst she has ever experienced for anti-abortion activity. "I'm aware of colleagues in other health board areas, such as Aberdeen, that are seeing protests that traditionally did not see activity like it."

Robert Colquhoun, founder of the UK chapter of anti-abortion group 40 Days For Life, is one reason for this increase in activity outside clinics. Colquhoun says he first encountered a prayer vigil organised by 40 Days For Life outside an abortion clinic more than a decade ago in Canada, which led him to set up a UK wing.

"We encourage Christians to pray and fast for an end to

## An anti-abortion protest in London on 4 September 2021

abortion," he says. The group conducts 40-day campaigns outside abortion clinics, usually to coincide with Lent or Christmas, during which people stand outside abortion clinics and pray.

They also hand out leaflets and hold up pictures of aborted fetuses, and they have been accused of harassing people who enter the clinics. "I understand it's a very emotional issue... but we're not there to harass people," says Colquhoun. "We are there to offer help."

Beyond protesting, anti-abortion activists also lobby policy-makers and organise events. Alithea Williams at the Society for the Protection of Unborn Children (SPUC) says the group organises a youth conference each year for about 200 people, and that SPUC sometimes goes into schools to give talks.



The group also encouraged its members to write to their members of parliament to prevent covid-19 laws allowing people to access abortion pills without visiting a clinic being made permanent, though this failed.

While the increase in anti-abortion activity comes at the same time as the overturning of *Roe v Wade*, the influence of the US anti-abortion movement on activists in the UK is unclear. Williams says the US plays little role in SPUC's thinking about abortion. "We have quite a different cultural context," she says.

But Lowe says there are parts of the movement currently that are clearly imported from the US. Campaigns organised by 40 Days For Life outside abortion clinics must first go through the US team, which charges a \$197 fee to help with organisation and provide campaign resources. The group even offers "early-bird" rates.

This infrastructure for connecting activists helps encourage them to take action, says Lowe. "For example, a group in Glasgow will find out very quickly that a group in Birmingham has 'saved a baby'... it kind of motivates them."

## Legal challenge

The use of litigation in the UK is also partly inspired by anti-abortion activists in the US, says Lowe. Last year, SPUC made a legal challenge over Northern Ireland's new abortion laws, arguing that they were unconstitutional. It was rejected by the High Court in Belfast in February.

Legal challenges have also made it costly to maintain or set up buffer zones around abortion clinics. There is no national regulation that prevents protesters from setting up camp close to an abortion clinic,

meaning local authorities have to handle them on a case-by-case basis.

Ealing Council used a public space and protection order (PSPO) in 2018 that prevented campaigners from 40 Days For Life protesting close to its abortion clinic. Local authorities in Richmond and Manchester have followed suit. But PSPOs aren't a perfect solution: they need to be

## "Harassment outside of clinics wouldn't be tolerated for any other healthcare service"

renewed every few years and are also subject to legal challenges, which can be costly for councils. "It makes policy-makers wary," says Louise McCudden at MSI Reproductive Choices, a charity in the UK.

The Royal College of GPs has backed a bill put forward by Gillian Mackay, a member of the Scottish parliament, calling for a 150-metre buffer zone around medical facilities that provide abortion services in Scotland. The bill, which is currently in its consultation phase, has also been backed by the country's first minister, Nicola Sturgeon.

It is unclear whether a similar law for other UK nations will be passed in the near future. A review by the UK's Home Office in 2018 found that a national buffer zone wouldn't be a "proportionate response".

Rupa Huq, Labour MP for Ealing Central and Acton, who has campaigned for national buffer zones, says something needs to change. "Women should not effectively be in an uneven, patchy postcode lottery in order to be able to access harassment-free reproductive healthcare," she says. "This is a national problem that requires a national solution." ■

## Space exploration

# Mars rover to get speed boost from software update

Matthew Sparkes

A NEW software update will soon give NASA's Curiosity Mars rover a 50 per cent speed boost, allowing it to cover a greater distance and complete more science.

Curiosity, which landed on Mars 10 years ago this month, has already greatly outlived its planned two-year lifespan. It can be controlled in several ways, but the vast majority of the time it operates in visual odometry (VO) mode. This means it stops at waypoints, which are usually a metre apart according to wheel rotation measurements, and uses photographs to calculate how far it has actually travelled. This can be vital because if the rover only tracked its movement using wheel rotations, big errors would creep in over time.

NASA has relied heavily on VO since earlier Mars rover missions using only internal sensors got irreparably stuck in sand. But this cautious approach comes with a trade-off in speed. Curiosity currently travels about 45 metres an hour in VO mode, despite the hardware itself being capable

of 120 metres per hour.

The updated software will allow Curiosity to take images of its surroundings while stationary, then check its prior resting position as it travels. It can subsequently compensate for any errors if they are found. This brings a small drop in accuracy, but allows the rover to move almost continuously. Tests showed that it would enable a speed of 83.2 metres an hour.

Mark Maimone at NASA's Jet Propulsion Laboratory in California, who works on the rover driving team, says the update will bring Curiosity nearer to the speed of its younger cousin, the Perseverance rover, which can cover around 135 metres an hour. "As a driver, of course we'd like to go faster, but we've come to really appreciate the benefits of having high-quality position estimates and being able to halt a drive before the wheels get embedded in sand," he says. "Since drive rates are expected to be 50 per cent faster on average, that will leave more power and time available for science observations."

The new software will be uploaded to Curiosity early next year and marks the end of three years of testing. ■

An artist's impression of the Curiosity rover on Mars



NASA/JPL-CALTECH

## Plant science

# Genetic tinkering increases soy yield by upgrading photosynthesis

Michael Le Page

SOYBEANS that have been genetically modified to make them more efficient at photosynthesis have produced yields more than 20 per cent larger than those of unmodified crops in field trials – and with no added fertiliser.

Growing these upgraded crops could help reduce deforestation, greenhouse gas emissions and the loss of biodiversity, as well as increasing the incomes of farmers in low-income countries for whom the crops are being created.

“We think it will work in most crops,” says Stephen Long at the University of Illinois Urbana-Champaign. “We are working on cowpea and we are working on rice.”

Several teams have managed to boost growth in plants such as tobacco by upgrading photosynthesis, but this is the first time it has been achieved in a food plant in field trials, says Long.

The work is the result of a global collaboration set up 10 years ago, mainly funded by the Bill & Melinda Gates Foundation, that aims to boost yields by improving

photosynthesis and to make these upgraded crops available to small farmers in sub-Saharan Africa. Several approaches are being explored and combining them should produce even bigger yield increases.

“We think we could get a boost as big as 50 per cent,” says Long. “If that could be achieved, it would be green revolution level.” The green revolution refers to the

**Rows of soybean plants grown in the GM crop trial**



HALEY AHLERS/RIPE PROJECT

major yield improvements achieved in the 1950s and 1960s thanks to improved crop varieties and other technologies.

The genetically modified soybeans have higher yields because they adapt better to changes from sun to shade, and vice versa. When a leaf is in full sunshine, it absorbs more light energy than its photosynthetic machinery can handle. This damages cells unless they turn on a mechanism known as quenching to dissipate the excess energy.

When a leaf is shaded, however, quenching has to be turned off to avoid dissipating energy that could be used. Most crop plants turn quenching on and off rather slowly, and lose a lot of energy as a result.

Some wild plants, such as ferns, turn quenching on or off much more rapidly, says Long. His team has added extra copies of three genes involved in the quenching process to the soybeans, which results in higher levels of the encoded proteins and speeds up the transitions, making photosynthesis more efficient (*Science*, doi.org/h8ns).

“Although we don’t fertilise our soybean crops, the protein content was unchanged,” says Long. That is important, given soya is the main plant source of protein globally.

“This study is very exciting,” says Emma Kovak at the Breakthrough Institute, a global research centre. “Not only do yield increases help reduce greenhouse gas emissions, but by reducing deforestation, they also help preserve plant biodiversity and wildlife habitat.” ■

## Astronomy

## The star Betelgeuse just keeps on acting weird

AS THE star known as Betelgeuse recovers from blasting out a huge amount of its innards in late 2019, an event that became known as the Great Dimming, its surface is now bouncing like gelatin on a plate, and it has lost its natural 400-day heartbeat that has been present for at least two centuries.

Andrea Dupree at the Harvard-Smithsonian Center for Astrophysics in Massachusetts and her

colleagues analysed observations from a slew of telescopes to unravel what happened in the Great Dimming and figure out what is behind the strange goings-on.

They found that the most likely cause of the dimming was a confluence of a hotspot on the star’s surface and a peak in the 400-day cycle in which the surface used to pulsate in and out.

When these two events happened at once, the researchers think that it caused a huge plume of material to blast off Betelgeuse, leaving a cool spot and a cloud of dust in its wake. The plume was

billions of times as massive as any ejection we have seen from the sun. “When you take out a big piece of the surface like that, it all kind of sloshes around like an unbalanced washing machine,” says Dupree.

This sloshing, which manifests as a sort of bouncing of Betelgeuse’s surface, is most likely to be caused by the plasma within the star rushing into the hole that the plume left. While the bouncing is currently

**“Betelgeuse’s surface is now bouncing like gelatin on a plate and it has lost its 400-day heartbeat”**

much faster than the natural pulsation, it is gradually slowing down (arXiv, doi.org/h8k9). “I would assume the pulsation is going to come back – but I just got some new measurements a few days ago, and it’s not there yet,” says Dupree.

None of this behaviour has been seen before in any other star. That is probably because very few other stars have been observed in the detail that Betelgeuse has, and it makes this a unique opportunity to learn about a strange phenomenon that probably affects other large stars as well, says Dupree. ■

Leah Crane



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Evolution

# Creature with mouth but no anus isn't human ancestor

Carissa Wong

OUR earliest ancestor may not be a tiny anusless sac with a huge mouth after all. The claim was first made in 2017, but new evidence suggests the creature, which lived around 530 million years ago during the early Cambrian period, was probably an early ancestor of animals such as crabs and spiders.

Fossils of the sac-like animal (*Saccorhytus coronarius*) collected from the Kuanchuanpu Formation

## 1.3

Length of *Saccorhytus coronarius* in millimetres

in South China suggest it was around 1.3 millimetres long and had a huge mouth – roughly half a millimetre wide – through which it probably both fed and excreted. It is thought to have lived on the sea floor.

"It would have either absorbed all of the matter it fed on or else the mouth served as an anus as well," says Philip Donoghue at the University of Bristol in the UK.

Simon Conway Morris at the University of Cambridge and his colleagues previously analysed 45 poorly preserved *S. coronarius* specimens and suggested that a set of small openings surrounding its mouth were the evolutionary precursors to gills that are now seen in fish. That, in turn, led them to propose that the creature was a common ancestor of deuterostomes, a broad group in the animal kingdom to which humans belong, making it our earliest known ancestor and that of all other vertebrates.

Donoghue and his colleagues now have evidence to say

this isn't the case. The team collected several hundred more *S. coronarius* specimens, many of which are well-preserved, by using a weak acid to dissolve hundreds of kilograms of rock from the same site in South China, revealing the fossils.

By imaging the specimens using a high-resolution technique called synchrotron tomography, the team found three-pointed spikes not seen in the previous fossils, suggesting that the supposed gill-precursors around *S. coronarius*'s mouth were probably holes left over from spikes that had broken off at their bases (*Nature*, doi.org/h8kh).

"We can see in our fossils that there was another layer of tissue preserved that extended up through these holes and created spines," says Donoghue. "Since the interpretation of those holes was the key evidence for interpreting the animal as a deuterostome, the lack of these openings basically pulls the rug from under that interpretation completely."

Instead, *S. coronarius* probably belonged to a major

### A reconstruction of *Saccorhytus coronarius*



group of animals called the ecdysozoans, which includes insects, crustaceans and roundworms. "It must have been some sort of predator, because of these spines, but we know absolutely nothing about what it ate," says Donoghue.

The findings suggest that *S. coronarius* cannot fill a gap in the fossil record that exists before the sudden appearance of a large diversity of animals. "It was argued that the common ancestors of deuterostomes were just so small that they are invisible in the fossil record. So *S. coronarius* being a deuterostome [which is now unlikely] would have supported that idea," says Donoghue.

Conway Morris declined to comment on the new work when contacted by *New Scientist*.

"There is no longer a strong case for interpreting *S. coronarius* as an early deuterostome," says Imran Rahman at the Natural History Museum in London. But that doesn't mean the hunt for other early deuterostomes – and perhaps our earliest ancestor – is over, he says. "I remain optimistic that, in the coming years, we will be able to piece together the earliest steps in deuterostome evolution based on fossil specimens." ■

Artificial intelligence

# Your phone could tell it's you just by the way you hold it

Jeremy Hsu

SMARTPHONES may be able to recognise individuals just from patterns in the vibrations of their hands. An algorithm trained to identify people this way did so with more than 90 per cent accuracy.

Gentian Jakllari at the Toulouse Institute of Computer Science Research in France and his team trained an artificially intelligent algorithm to identify an individual by the way they hold a smartphone.

The team recruited 217 volunteers to each hold such a device while its sensors collected data during either a single 30-second measurement session or a series of such sessions. The AI used about half of the data to figure out the best way to differentiate individual smartphone users.

The researchers then tested the algorithm with the other half of the data to see if it could identify specific individuals in the group. Across 1100 tests, the algorithm identified the correct person around 92.5 per cent of the time within 1.5 seconds (*Proceedings of the ACM*, doi.org/h8k8).

The system could eventually be used as a form of password. One of the main problems for it at the moment is that other movement affects the accuracy. "If you are in a car or train, for example... the vehicle motion will essentially drown out the signal," says Kevin Jiokeng at the University of Lille in France, part of the team.

Other researchers have faced similar challenges when studying signals like those used for monitoring heart health, says Omer Inan at the Georgia Institute of Technology. He also says that if the system were to be used as a way to authenticate who was holding a device, the accuracy would need to hold up while users are undergoing heavy exercise or stress that could subsequently affect the vibrations in their hands. ■

## Particle physics

# Proton's charming nature revealed

Despite it being found in every atom, we are still learning more about the proton

Alex Wilkins

THE proton appears to have a more complicated structure than is traditionally given in textbooks.

While protons were once thought to be indivisible, experiments with particle accelerators in the 1960s revealed that they contained three smaller particles, called quarks. Quarks come in six types, or flavours, and the proton contains two up quarks and one down quark.

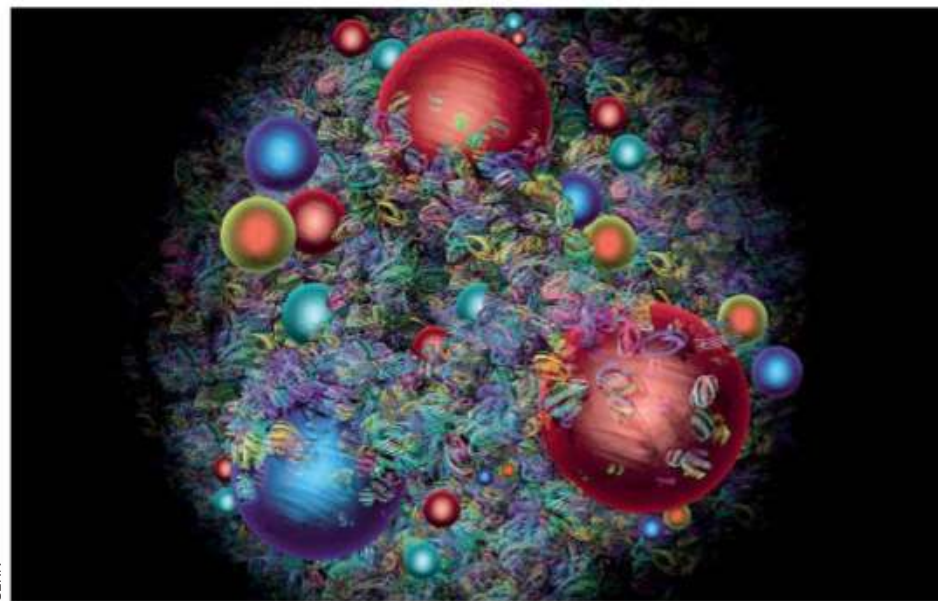
But in quantum mechanics, a particle's structure is governed by probabilities, meaning there is theoretically a chance that other quarks could crop up inside the proton in the form of matter-antimatter pairs. An experiment at the European Muon Collaboration at CERN in 1980 hinted the proton might contain a charm quark and its antimatter equivalent, an anticharm, but the results were inconclusive and hotly debated.

There were further attempts to identify the proton's charm component, but different groups found conflicting results and had difficulty separating the intrinsic building blocks of a proton from

the high-energy environment of particle accelerators, where every kind of quark is created and destroyed in rapid succession.

Now, Juan Rojo at Vrije University Amsterdam in the Netherlands and his colleagues have found evidence that a small part of the proton's momentum, around 0.5 per cent, comes from the charm quark. "It's remarkable

**This proton contains two up quarks (large red spheres) and a down quark (large blue sphere)**



CERN

that even after all these decades of study, we're still finding new properties of the proton and, in particular, new constituents," says Rojo.

To isolate the charm component, Rojo and his team used a machine learning model to come up with hypothetical proton structures consisting of all the different flavours of quarks. They then compared them with the results of more than 500,000 real-world collisions from decades of particle accelerator experiments.

The researchers found that, if the proton doesn't contain a charm-anticharm quark pair, there is only a 0.3 per cent chance of seeing the results they examined. Physicists call this a "3-sigma" result, which is normally seen as a potential sign of something interesting. More work is needed to boost this to 5-sigma level, meaning about a 1 in 3.5 million chance of a fluke result, which is traditionally the threshold for a discovery (*Nature*, doi.org/h8km).

The researchers looked at recent results from the LHCb Z-boson experiment and modelled the statistical distribution of the proton's momentum both with and without a charm quark. They found the model better matched the results if the proton is assumed to have a charm quark. This means they are more confident in proposing the presence of a charm quark than the sigma level by itself suggests.

"The fact that very different studies converge on the same result made us especially confident that our results were solid," says Rojo. ■

## Biotechnology

## Living robots may be able to help repair neurons

BIOLOGICAL robots made of human tracheal cells can promote the repair of wounded neural tissue in the lab. While the research is still at an early stage, the findings suggest that the robots could one day treat the cellular damage that can occur after a stroke or with paralysis.

In 2020, Michael Levin at Tufts University in Massachusetts and his colleagues created living robots, called xenobots, out of frog cells.

A year later, they were surprised to find the xenobots can self-replicate.

In their latest work, they grew single tracheal cells, donated from people, over three weeks to form mobile clusters of cells called anthrobots, which ranged from 30 to 500 micrometres wide. Using human cells rather than frog ones reduces the risk of the robots being rejected by the immune system.

The anthrobots are covered in tiny hair-like structures called cilia, which act like flexible oars to propel them at up to 50 micrometres per second. Once formed, the bots can survive in laboratory conditions for

four to six weeks before degrading.

When adding multiple anthrobots to a dish, the team discovered they aggregate into larger "superbots", each made of a few anthrobots.

To see if superbots influence healing, the researchers grew a sheet of human neural cells in a dish before scratching off some of the cells to generate a "wound" roughly half a millimetre wide. They then placed the superbots at sites

**"Once formed, the bots can survive in laboratory conditions for four to six weeks before degrading"**

along the wound to form a bridge between neurons on either side.

Within three days, neural tissue had grown across the wound beneath the bridges. Tissue growth didn't occur at other sites along the scratch, suggesting that the superbots induced the healing (bioRxiv, doi.org/h8kk).

That a single human tracheal cell can proliferate and form a colony to become a self-propelling, functional machine is unexpected, says Taher Saif at the University of Illinois Urbana-Champaign. "The capability of this machine... is fascinating." ■ Carissa Wong

## Biotechnology

# Tiny DNA-testing chip could combine many medical tests

Matthew Sparkes

A TEST that can detect hundreds of thousands of different fragments of DNA sequences, proteins or antibodies could be built onto a tiny silicon chip. Researchers say the technology could lead to devices for medical diagnostics or environmental monitoring.

Jack Hu at Stanford University in California and his colleagues created a metamaterial from silicon that can identify gene fragments just 22 nucleotides long within 5 minutes. When a sample is placed on the chip and near-infrared light is shone on one side of the material, microscopic antennae focus it onto specific spots on the other side that each correspond to a positive test for a different fragment.

A square centimetre of this metamaterial can have more than 200,000 of these spots that recognise different molecules. Although the spots of light would be impossible to detect with the human eye, they can be monitored with a camera sensor to provide virtually instantaneous detection (arXiv, doi.org/h8n7).

The metamaterial is made in silicon using techniques from the computer chip-manufacturing industry, so it could potentially be created cheaply and at scale. Hu says millions of the nano-antennae that detect different molecules could be put into a single chip, and could potentially create a single, universal medical sensor.

"In biological systems, there are millions and billions of different kinds of signals, or information contained in different kinds of biomarkers, and generally the way we probe them now is kind of like trying to piece together a lot of disparate assays and tests to try to put together a picture of someone's holistic health," he says. "But I think [that with] these technologies, you start to be able to put together a lot of these assays into one device." ■

## Geology

# A second asteroid may have struck at end of dinosaur era

Michael Le Page



SERPBLU/SHUTTERSTOCK

WHAT appears to be a 9-kilometre-wide crater has been discovered buried beneath the sea floor near the coast of West Africa. It is thought to have been made around the time of the larger Chicxulub impact that wiped out most dinosaurs, leading to speculation that it was caused by a chunk that broke off the Chicxulub asteroid.

"It definitely fits the bill for an impact crater," says Uisdean Nicholson at Heriot-Watt University in Edinburgh, UK.

Nicholson spotted the feature in seismic reflection data supplied by the oil and gas industry. The likely crater, named the Nadir crater after a nearby seamount, is on the continental shelf a few hundred kilometres off the coast of Guinea, buried beneath around 300 metres of sediment in an area where the water is 900 metres deep.

The structure has all the features characteristic of an impact crater of this size, says Nicholson, including a raised rim and signs of ejected material outside the crater itself. Modelling by team member Veronica Bray at the University

of Arizona in Tucson suggests it was caused by the impact of an asteroid around 400 metres in diameter (*Science Advances*, doi.org/gqn3qw).

The Nadir crater appears to have formed around 66 million years ago, the same time as the 180-kilometre-wide Chicxulub crater in what is now Mexico.

## 400m

Estimated diameter of asteroid that created the Nadir crater

That has led the team to speculate that it was made by a chunk that broke off the Chicxulub asteroid, which is estimated to have been 13 kilometres in diameter.

If this had happened just before impact, the two craters would be very close. Instead, Nicholson suggests that gravity could have broken the asteroid apart during an earlier orbit that passed close to Earth, leading to two impacts within a few days of each other.

This is what happened with the Shoemaker-Levy comet, says Nicholson, which was ripped into fragments by

Dinosaurs may have been hit by two or more space rocks

Jupiter's gravity in 1992 and then struck the planet in 1994. At least 21 fragments hit Jupiter over a six-day period.

It is possible that the Chicxulub asteroid broke up into several fragments too, says Nicholson. Other impact craters may remain to be discovered or could have been destroyed by tectonic processes. Craters don't form when asteroids hit water several kilometres deep, as most of our oceans are.

"This is an exciting discovery," says Gareth Collins at Imperial College London, who has studied the Chicxulub impact. "It certainly has lots of features consistent with an impact origin."

However, Collins isn't convinced that the event is linked to the Chicxulub impact, pointing out that there is a lot of uncertainty in the dating. "I think that the two events are more likely to be unrelated," he says.

Nicholson thinks this is a possibility. His team has put in a proposal to drill through the Nadir crater and retrieve cores that will confirm if it is an impact structure and allow the event to be much more precisely dated.

The Nadir impact alone wouldn't have caused a major extinction, says Nicholson. The event would have mostly affected the surrounding region, not least by creating tsunami waves that would have been 500 metres high near the impact site, according to the study. "It would have been a very significant regional event," he says. ■

## Palaeontology

### Megalodon could easily eat a whale

MEGALODON, an ancient shark, could have eaten an 8-metre-long whale in just a few bites, according to the first 3D reconstruction of the predator. This new description upgrades its size to 16 metres long and a weight of 61.5 tonnes.

John Hutchinson at The Royal Veterinary College in the UK and his colleagues reconstructed megalodon using fossilised vertebrae and teeth and software usually used for dinosaurs (*Science Advances*, doi.org/gqnxz3).

The resulting 3D image gives a fairly good idea of what megalodon would have looked like, inside and out, says Hutchinson. It required 20 times more calories per day than a modern great white shark, he says, and would have consumed an 8-metre-long animal in only five bites. **Christa Lesté-Lasserre**



## Chemistry

### Plastic upcycled into more valuable items

RESEARCHERS have found a way to upcycle plastic waste into more valuable products, which they say could help tackle the growing accumulation of non-degradable waste polluting our cities and threatening life in our oceans.

Guoliang Liu at Virginia Tech and his colleagues have developed a method to break down polystyrene and convert it into a chemical that is 10 times more valuable than polystyrene, so the conversion creates an economic incentive to reduce polystyrene waste. The process is energy efficient and adaptable to other plastics, the researchers say.

The reaction requires less energy than existing methods of recycling or upcycling polystyrene. The process is easy to adopt and could be profitable at a large scale, according to the team (*PNAS*, doi.org/gqnss5). **Luke Taylor**

## Biomechanics

### Chewing uses a surprising amount of energy

CHEWING can increase bodily energy expenditure by up to 15 per cent.

Adam van Casteren at the University of Manchester in the UK and his colleagues measured energy use in 21 people between 18 and 45 years old as they chewed gum for 15 minutes. The gum was tasteless, calorie-free and odourless. "This way it doesn't activate the digestive system to the same extent as it otherwise would," says van Casteren. "We wanted to measure just chewing or as close to chewing as we could get."

Each participant was asked to chew two types of gum – one soft and the other stiff – so the team could compare the effects of these properties on the

energy use of the volunteers.

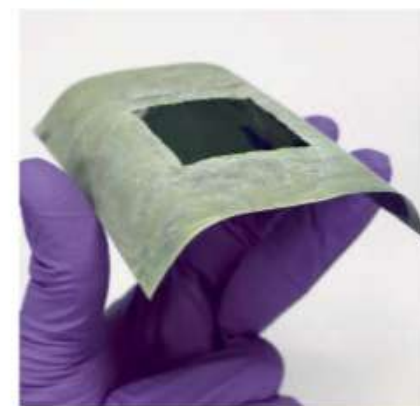
Energy expenditure was measured using a plastic dome covering the participants' heads. A monitor inside the dome measured oxygen intake and the amount of carbon dioxide released. "You can use this information to work out how much energy is being expended," says van Casteren.

The researchers found that chewing the soft gum elevated energy expenditure by about 10 per cent, while chewing the stiffer gum increased it by around 15 per cent (*Science Advances*, doi.org/gqnx3m).

Van Casteren says he expects the energy used to chew real food will be even larger as many foods require a lot of effort to break down.

The findings suggest that the energy expenditure needed to chew may also explain why we developed strong teeth and jaws for the action. Any amount of energy lost while chewing food makes the meal a less efficient source of energy. **Jason Arunn Murugesu**

## Really brief



### Floating artificial leaf produces fuel

An artificial leaf that uses sunlight to produce ingredients for fuel is light enough to float on water. The device produces bubbles of carbon monoxide and hydrogen, which can be mixed together to make a fuel called syngas (*Nature*, doi.org/h8nq).

### How Arctic fish keep blood from freezing

The variegated snailfish (*Liparis gibbus*), found in cold waters off Greenland, produces soaring levels of antifreeze proteins. These bind to water to limit the size of ice crystal formation, preventing blood from freezing solid (*Evolutionary Bioinformatics*, doi.org/gqnszs).

### Toxic content abounds on Reddit

More than one in eight Reddit users publish toxic content, according to an analysis of more than 2 billion posts and comments on the social media platform. A neural network categorised the posts after being trained on a smaller sample that had had its toxicity judged by people (*PeerJ Computer Science*, doi.org/gqn386).



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**Culture columnist**  
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## Comment

# Space for everyone

Some scientists are unhappy about the James Webb Space Telescope's data being made public immediately, but these images should be for all, says **Jacob Aron**

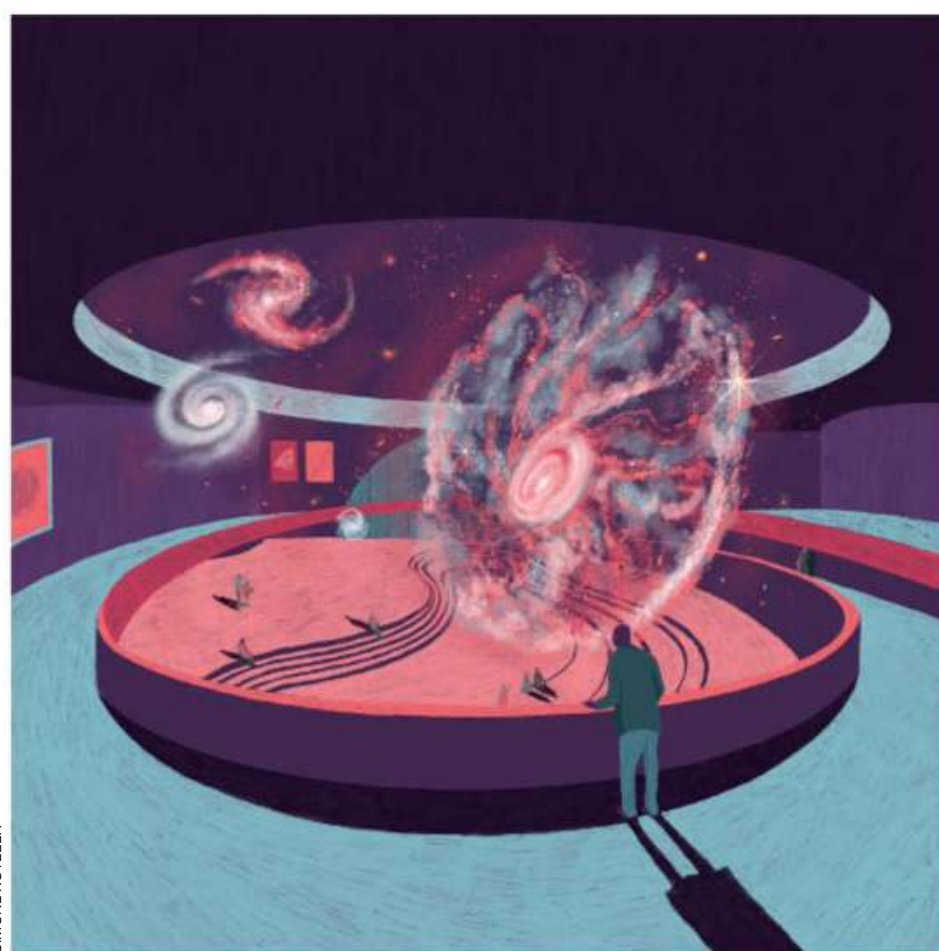
**W**HEN the first image from the James Webb Space Telescope (JWST) was unveiled by US president Joe Biden on 11 July, I was stunned. Even the low-quality video stream I was watching made it clear that JWST's "deep field" picture, containing thousands of galaxies and billions of stars, was something special, but the real fun began once I downloaded the high-resolution image and could explore the cosmos at leisure.

I wasn't alone – my Twitter feed was full of people sharing their favourite finds and revelling in the sheer majesty of it all. And beyond the pretty picture, teams of scientists around the world had already begun analysing the newly released data, hoping to be the first to unlock its secrets.

*New Scientist* has already published dozens of stories on the work these teams are doing. But some researchers are unhappy about the pace at which JWST papers are coming out, arguing that it isn't possible to produce good science in just days or weeks, and that a more limited release of data to a select pool of researchers would have been preferred.

I disagree, for two reasons. The first is that I strongly believe science done in public is always better than science done in private, because more eyeballs means more scrutiny of the results. Formal peer-review in a top-tier scientific journal is important, but not infallible.

Take the case of supposed



SIMONE ROTELLA

arsenic-based bacteria, which was published in *Science* in 2010 and began unravelling just days after other researchers saw the paper. Or a claimed technique for turning adult cells into stem cells, published in *Nature* in 2014 and retracted six months later under a wave of controversy. Those cases had minimal impact on the world, but a 1998 paper in *The Lancet* that falsely linked the MMR vaccine with autism reverberates today, years after it was retracted.

It is unlikely that incorrect research in astronomy could have a similar effect, but by making JWST's data public, researchers

everywhere can investigate it, and interrogate each other's results, immediately. What's more, reporting on this process, as my colleague Leah Crane did with her story on competing claims for the most distant galaxy discovered by JWST, shows science as it really is: a messy endeavour that inches towards conclusions, rather than handing down iron-clad truths.

The second reason is perhaps more selfish, but I think equally important. JWST cost \$10 billion, the majority of which came from NASA's budget, but the European and Canadian space agencies also contributed. All three are

ultimately funded by taxpayers in Europe and North America, so in a very real sense, I paid for JWST, as did many *New Scientist* readers. Why shouldn't we be able to enjoy its images, as soon as they are out?

Some scientists argue this is unfair – yes, the telescope is publicly funded, but people have devoted decades of their career to designing, building and launching it. Shouldn't they get a crack at the data before some random astronomer scoops their find?

I have sympathy, but I think ultimately the public interest outweighs the need for career progression. In 2014, I reported live from mission control as ESA's Philae lander touched down on the surface of comet 67P. There was massive public excitement about the mission, and the photos were stunning – at least those we were allowed to see.

Philae's mothership, Rosetta, had a high-resolution camera that took thousands of photos, but thanks to ESA rules allowing the camera team a year to analyse the data in private, only a handful were released in real time. Millions of space enthusiasts were deprived of the ability to follow Rosetta and Philae's journey in full – something that won't happen with JWST. I can't wait to see what it reveals next. ■



Jacob Aron is *New Scientist's* news editor. Follow him @jjaron

## My botanical life

**Walls of life** Green roofs have existed for more than 2000 years, but, along with living walls, they are becoming more popular – and provide major eco-benefits, writes **Beronda L. Montgomery**



Beronda L. Montgomery is a writer, researcher and biochemist who studies how plants detect and respond to their local light environment. She is the author of *Lessons from Plants*. You can follow her on Twitter @BerondaM

**S**OME of my favourite writing spaces of late have had a living wall – a vertical garden of plants – or a bountiful green roof. There is something very soothing to me about being in a space with a visible, robust community of plants.

Green roofs aren't new: they have been reported to exist as early as 500 BC, in the Hanging Gardens of Babylon. But they appear to have become more common recently, or at least my noticing of them has become more frequent. I have seen them at hotels, restaurants and my current and former workspaces.

Living walls and green roofs are composed of plants growing in soil or in a hydroponic system, which is a method for growing plants in a water-based nutrient solution. *Pothos* varieties and ferns often feature on living walls, while sedums and other succulents that can resist dry conditions are prevalent on roofs.

Living walls can be found indoors or on the outside walls of buildings. They can also be installed in or on commercial buildings or, at a smaller scale, in homes, with herb gardens being a popular choice for homeowners.

Given the vertical nature of growth, living walls often have an integrated watering system that is designed to add to their eco-sustainability. They improve air quality by taking up carbon dioxide for photosynthesis and releasing oxygen.

Outdoor living walls also help with insulation and temperature control and, like green roofs, will contribute to sustainable drainage by absorbing the rainwater that could otherwise run into storm drains and increase flooding risks.

Living walls' greatest attribute, though, may be aesthetic: they are living pieces of art. And this is art

that has a health benefit, not only because plants provide oxygen and filter water, but because engaging actively in plant care can improve mental health.

Green roofs, meanwhile, can have both economic and sustainability benefits. Their plants grow in a substrate, such as soil, placed over a waterproofing system or in containers. This helps green roofs to provide protection against exposure to wind, excess light – including damaging ultraviolet rays – and surplus

**“By retaining heat in winter and soaking up the summer sun, green roofs reduce the need for air conditioning”**

water. They may also serve as barriers against noise in more densely populated areas.

One of the most frequently advertised benefits of green roofs is the energy efficiency that they add to buildings by serving as insulation. By limiting heat loss in winter and absorbing sunlight in summer, they reduce the need for air conditioning and heating, and thus save money.

Green roofs are also reported to act as fire retardants, which may lead to their increased use in places such as the western US, where wildfires have been steadily increasing in frequency and intensity.

Although they are found at greater scale on commercial properties, green roofs are also growing in popularity for homes. Costs for home installation vary depending on the types of plant selected. On top of this, not all walls or roofs are sufficiently structurally sound to have such greenery installed. Green roofs,

in particular, may need structural reinforcement due to the extra load produced by substrate, water and containers, which brings additional costs.

Living walls and green roofs also have ongoing costs for upkeep – both financial and labour – that should be considered. Living walls, for example, have lifespans of 10 to 15 years before they need to be replaced, which depends on their substrate, what their plant life cycle is, their size and their mechanical components.

Both green walls and roofs require significant tending to ensure that their plants' roots don't escape from the soil or their hydroponic systems. Roots have an uncanny way of growing through things that seem impenetrable, like walls, bricks or pipes, so without proper care there is the potential for root-associated structural damage. This means that plants with shallow or fine root systems, such as the *Pothos* and sedums I mentioned earlier, are excellent choices.

The moisture associated with plants in living walls and green roofs must also be monitored to ensure that it doesn't cause damage to structures, as green roofs can be more susceptible to leakage. As well as structural work, and the necessity of limiting root-related damage, green roofs also need landscaping care and regular watering to remain healthy and nurtured.

While there are potential drawbacks, in most cases the benefits of these burgeoning green spaces outweigh the challenges, in terms of both their ecological implications and the joy that having a thriving community of plants can bring. Living walls and green roofs are a welcome addition to support people's health and well-being. ■

## Beronda's week

### What I'm reading

The Wake Up: Closing the gap between good intentions and real change by Michelle Mijung Kim

### What I'm watching

Street Food: USA, as much a travel guide to several cities as it is a collection of human-interest stories about some amazing cooks and regional foods

### What I'm working on

I'm collaborating on a series of articles about mentoring ecosystems

This column appears monthly. Up next week: Chanda Prescod-Weinstein

# Signal Boost

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Paul Strickland Scanner Centre**



## WHAT DOCTORS SAY ABOUT US



**"The radiologists at the centre focus on extremely complex scans and the centre benefits from very advanced, up to date scanners and software. Paul Strickland Scanner Centre adds enormous value to Mount**

**Vernon Cancer Centre because the team is so specialised in cancer imaging. This ultimately benefits patients' treatment."**

Dr Jeanette Dickson, Consultant Oncologist at Mount Vernon Cancer Centre and President of the Royal College of Radiologists

## WHAT OUR PATIENTS SAY



**"I have a whole-body MRI scan every 8 weeks to keep check on the size and shape of my cancer. Without Paul Strickland Scanner Centre and my oncology team, who knows where I would be."**

Sarah, Paul Strickland Scanner Centre patient and supporter

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increasingly important imaging technique in personalised medicine, and have done more scans of this type than any other centre in the world.

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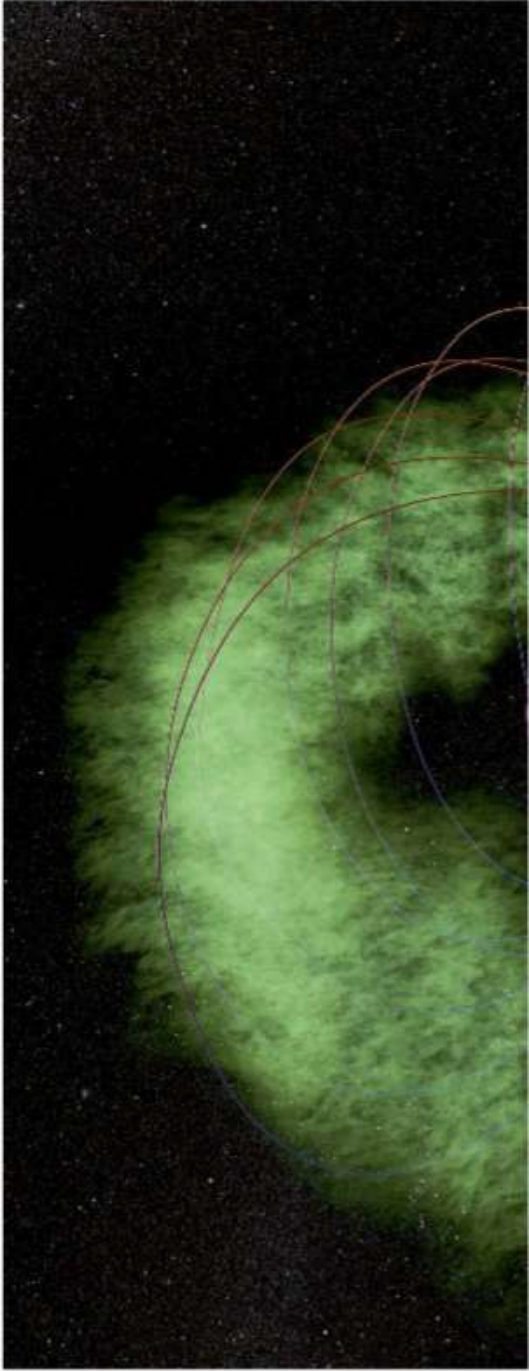
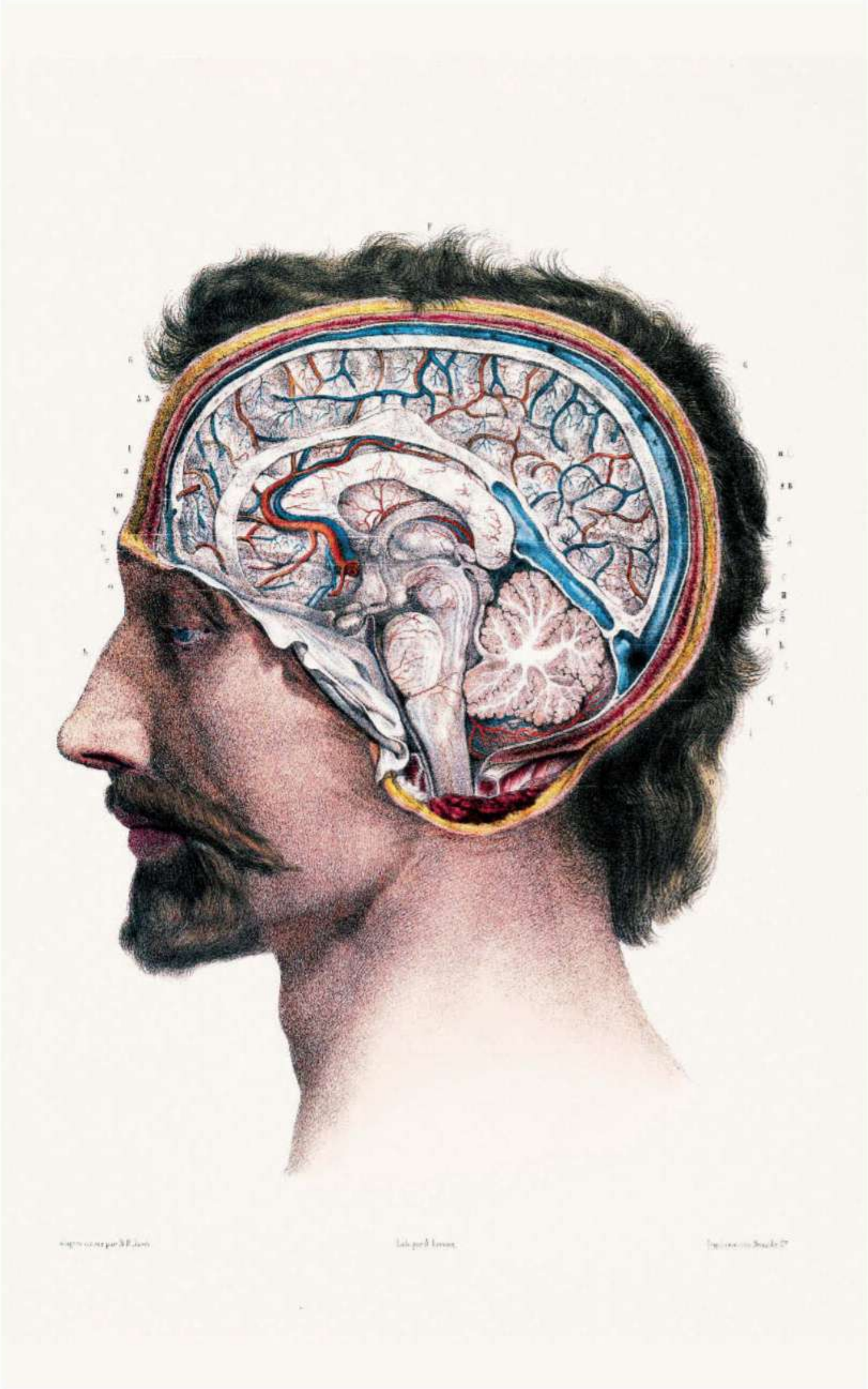
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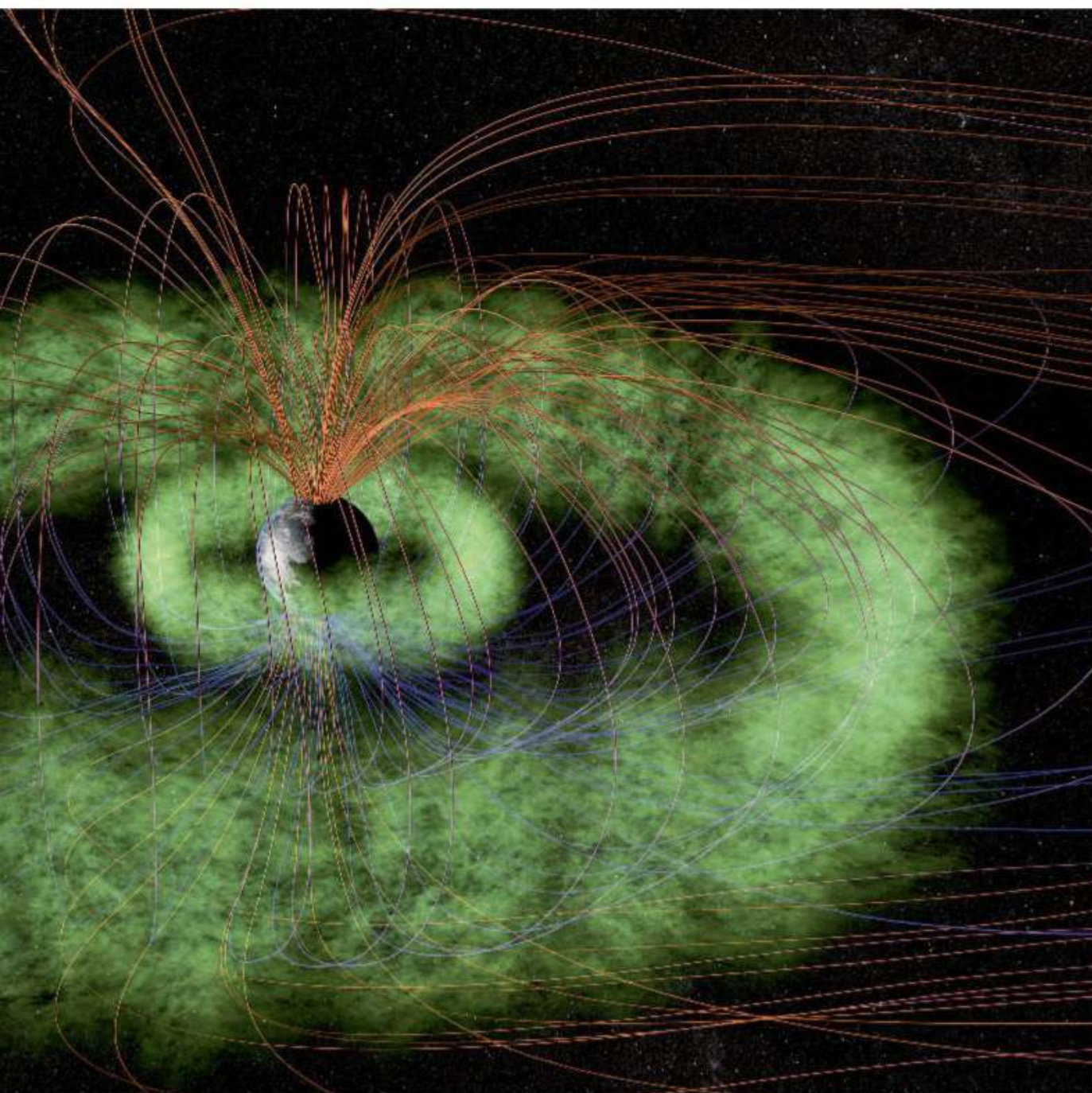
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## Picture this



THESE seminal scientific images, taken from the new book *Science Illustration: A history of visual knowledge from the 15th century to today* by Anna Escardó (published by Taschen), are more than just a treat for the eyes.

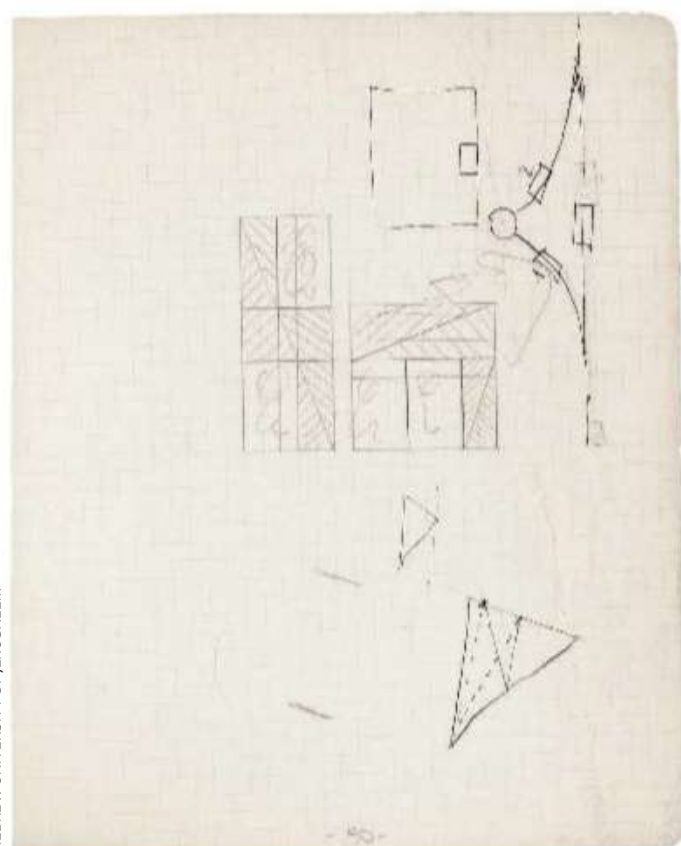
The lateral view of the human brain, shown far left, is taken from French physician and anatomist Jean-Baptiste Marc Bourguery's *Atlas of Human Anatomy and Surgery*. First published in 1831, this textbook is known as the most comprehensive ever produced on human anatomy.

The three bottom images show, from left to right: nerve synapses called the calyces of Held, drawn in 1934 by Santiago Ramón y Cajal, whose neuron doctrine showed that the nervous system isn't continuous, but is made from discrete cells; Albert Einstein's 1905 sketch of a puzzle game from his relativity notebook; and watercolour illustrations of the moon by Galileo Galilei, based on observations made with a telescope he constructed in 1609 that was powerful enough to examine objects in the night sky.

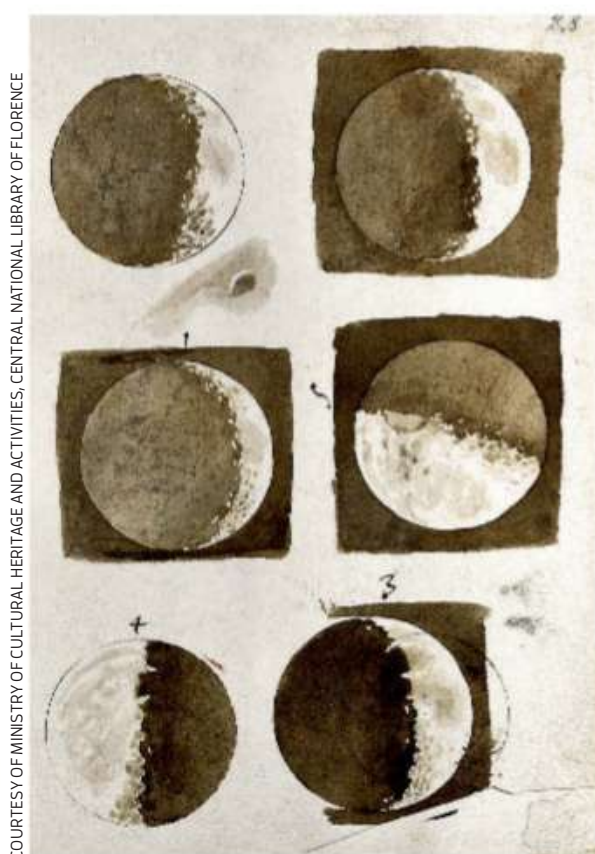
Shown top right is NASA's 2012 image of two "doughnuts" of charged particles, or plasma, surrounding Earth, an example of how computer graphics have created more precise and realistic depictions of invisible phenomena. These rings are called Van Allen radiation belts. NASA launched two probes in 2012 to better understand these regions and space weather more widely.

"Scientific illustrations allow the conveyance... of complex scientific concepts," says Escardó. "Even today... it is still necessary to use illustration as a tool to capture images that can only be made through this medium." ■

**Gege Li**



HEBREW UNIVERSITY OF JERUSALEM



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## Editor's pick

### Grappling with the mysteries of early Earth

13 August, p 46

From Jim McHardy, Clydebank, West Dunbartonshire, UK

In your look at when oceans, land and life emerged on Earth, the debate over where Earth's water came from was raised.

Another planet, Theia, is thought to have struck the infant Earth, perhaps after coming from the outer solar system, which is the source of icy comets, to orbit the sun ahead or behind our planet. Eventually, maybe due to perturbations from Venus and Jupiter, Theia is thought to have collided slowly with Earth, almost melting it and creating the moon from debris blasted into orbit.

If Theia was rocky and covered in a thick layer of water ice, this impact would have allowed most of its ice to be ejected into orbit while its core coalesced with Earth. Ice and water in orbit would have been chilled and eventually swept up by Earth.

The atmosphere would then have contained a large volume of turbulent water vapour, radiating heat into space while simultaneously reflecting more of the early sun's radiation. This would result in more rapid cooling of the planet's surface at an earlier stage.

From Fred White, Nottingham, UK  
When proto-Earth was struck by Theia, I assume its orbital parameters were altered. Is anyone looking into the scale of such a change? Could it have brought the combined bodies into the habitable zone?

### On the subject of noise, let's talk about sirens

13 August, p 38

From Ronnie Horesh, Chester, UK  
Your cover story "Shhhhh..." draws attention to health problems aggravated by loud or unexpected noise. I believe the contribution of emergency vehicle sirens to anxiety, depression and

other conditions is ignored due to their multifactorial origins.

A fruitful research area, now that most vehicles contain sophisticated electronics, would be to look into more subtle and focused ways of warning people of approaching emergency vehicles.

### Could we tap old mines as a new source of water?

Leader, 13 August

From Alan Jowett, Castlemorris, Pembrokeshire, UK

I have reservations about large reservoir development to address water shortages, as it invariably disrupts communities and may reduce available farmland.

There are vast water reserves in old mine workings. If coal is now redundant as an acceptable fuel, then we could repurpose mine galleries, tunnels and shafts that hold significant amounts of water. Using it would entail purification and decontamination, but that takes place with even the most pristine of surface reservoirs.

### Problem is, our thirst for energy is unstoppable

13 August, p 25

From John Gouk, Reading, Berkshire, UK  
Eugene Linden suggests drilling with millimetre-wave beams to access deep geothermal heat, a supply of energy that isn't liable to the intermittency that affects wind and solar. So, problem solved?

Sadly, such advances would do little to remove the problem of our constant growth in energy use. US figures show 2.9 per cent compound annual growth from 1650 to 2009. The *Do The Math* blog details how, unchecked, our increasing demand results in the entire energy of the sun

being required in 1400 years.

At best, geothermal energy could provide an alternative that enables us to stop using fossil fuels, but it isn't a total solution in the sense of allowing human civilisation to endure long term.

### Only way forward is to keep new coal in ground

Letters, 13 August

From Barry Cash, Bristol, UK  
Richard Mellish makes a logical argument for the opening of a new coal mine in Cumbria. However, he has overlooked the law of supply and demand. If there is an extra supply of coal, the price will fall and more will be used. His argument would be valid if the opening of a Cumbrian mine caused a mine somewhere else to close. However, it won't.

The only way to reduce fossil fuel use is to stop opening more mines and oil wells.

### Mind your language to advance climate cause

6 August, p 29

From Emma Martins, St Ouen, Jersey, Channel Islands  
Bill McGuire talks of the need for a public information campaign about the climate emergency to educate people and trigger action. He is absolutely right, but we need so much more.

I watched a TV weather forecast during the recent heatwaves that talked of the "beautiful" weekend ahead and "perfect BBQ weather". An announcement I heard on public transport finished with "enjoy the weekend, it's gonna be another gorgeous one".

Climate change is neither beautiful nor gorgeous, it is catastrophic. Language matters. It is up to all of us to change the

narrative. Government needs to play its part, the rest of us do too.

### Not immoral? The fossil fuel industry?

Letters, 16 July

From Nick Tigg, Lewes, East Sussex, UK

I was amazed to see a letter claiming fossil fuel production was neither illegal nor immoral. Really? The oil and gas industry has known for decades that its activities aren't just heating Earth, but causing devastating pollution and leading to a planet that will be uninhabitable.

Knowingly contributing to the possible extinction of human and other life on Earth would seem to me, and I imagine most people, the very definition of immoral.

### Rumours of AI's death are exaggerated

Letters, 6 August

From Steve Dalton, Chipstead, Kent, UK  
David Hodgson fears that "terminating" a sentient AI could be seen as murder. Switching off a computer program, no matter how complex, is reversible provided its state has been written to persistent storage. A murder trial might struggle to convict if the defence can call the victim to the stand.

### Living green on energy drinks and fizzy pop

13 August, p 13

From Eric Kvaalen, Les Essarts-le-Roi, France  
Thank you for the article on the environmental impacts of various foods and drinks. As a result of reading it, I have resolved to do my part for the environment by living on Red Bull and Coke. ■

### For the record

■ The crater lakes shown on São Miguel in the Azores are volcanic, rather than the result of impacts (6 August, p 45).



### Want to get in touch?

Send letters to [letters@newscientist.com](mailto:letters@newscientist.com); see terms at [newscientist.com/letters](https://www.newscientist.com/letters)

Letters sent to New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT will be delayed

# Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

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Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

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**"As scientists, our duty is to secure the future of research for the generations that follow."**

Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that



research forward, are the key to meeting those challenges for years to come.

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

**I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact**

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# The making of Gaia

Letters between the two scientists who co-developed the paradigm-changing Gaia hypothesis make for fascinating reading, says **Adam Vaughan**



Book

## Writing Gaia

Edited by **Bruce Clarke**  
and **Sébastien Dutreuil**  
Cambridge University Press

HERE'S something for the archive: "The *New Scientist* one seems to have stirred up some interest including an amazing number of crank letters of a gentle and non-aggressive kind," wrote the late independent scientist and polymath James Lovelock, in a letter to biologist Lynn Margulis.

The "cranks" were responding to an article in this magazine, dated 6 February 1975. In it, Lovelock presented the idea and world view of Earth as a self-regulating system, the Gaia hypothesis, to a wider audience.

The article worked. It led to Lovelock's first book, 1979's *Gaia: A new look at life on Earth*, an important first step in taking the concept beyond scholarly halls to a broader public.

The letter is one of 268 pieces of previously unpublished correspondence in an edited collection spanning 1970 to 2007.



*Writing Gaia: The scientific correspondence of James Lovelock and Lynn Margulis* charts the inside story of a long-running collaboration that gave birth to one of most influential environmental ideas in the modern world. The letters document the duo's efforts to win over opponents and to amass enough evidence to move the Gaia hypothesis from idea to theory.

While many readers will be drawn to the book for insights about Lovelock, who died last month aged 103, Margulis is



**James Lovelock and Lynn Margulis corresponded for nearly 40 years**

any correspondence, there is also a fair slice of everyday life, from him moaning about the Boston postal service to her complaining about his ever-changing phone number.

Overall, much will only appeal to academics who are interested in the details of how the two merged their understanding of atmospheric science and biology, how they got papers published in certain journals and how they gradually won over critics.

Yet there is something for a general reader, too. Alongside insights into how the two minds collaborated on a vital idea, there is human interest in watching how exchanges swing from warm and intimate to quarrelsome and sarcastic at points.

A nadir comes in 1981, when Lovelock reports a "bad few days" after Margulis publicly criticised his book. She shoots back, asking "what would our relationship be worth if I weren't entirely straight with you". Happily for us, despite their differences, they kept writing for decades. ■

L-R: TIM CUFF/ALAMY; NANCY R. SCHIFF/GETTY IMAGES

## UFO sci-fi horror is a must-see



Film

## Nope

Jordan Peele  
On general release

SOMETHING strange is lurking in the clouds above a dusty, unassuming valley deep in southern California. On a horse ranch, taciturn Otis "OJ" Haywood Jr and his sister, the somewhat livelier Emerald, are struggling

to save their business, Haywood's Hollywood Horses, which supplies horses for film and television. Six months earlier, their father, who founded the business, was killed when a nickel mysteriously fell out of the sky, hitting him in the eye.

The strange something lurking in the clouds turns out to be a saucer-shaped UFO, which OJ spots when it begins abducting his horses, expelling any non-fleshy objects in the process.

Most people would probably

choose to flee after discovering this potentially life-threatening entity in their backyard, but not the Haywood siblings. Instead, they embark on a mission to capture the UFO on film, driven by a desire for fame, fortune and, importantly for OJ, the need to keep their father's legacy alive. What follows is an action-packed, if gruesome, UFO-hunting adventure.

Despite adopting the flying saucer cliché, Jordan Peele's

beautifully shot spectacle breathes new life into the sci-fi horror genre. Though it isn't as politically biting as the director's previous horror outings, *Get Out* and *Us*, the film sprinkles in cautionary allegories about animal exploitation and modern society's toxic ability to immerse itself in drama. Ultimately, a satisfying and suspenseful final act makes *Nope* a thrilling must-watch, stuffed full of ideas. ■

Chen Ly

# Genetics, for good or bad

This thought-provoking new history asks whether genetic engineering is worth the effort, finds **Michael Marshall**



**Book**  
**The Genetic Age**  
Matthew Cobb  
Profile Books

FOR more than 50 years, biologists have been genetically engineering organisms in increasingly precise ways. From the early, crude methods of the 1960s and 1970s, to the modern “gene editing” exemplified by CRISPR technology, genetic engineering has elicited great hopes and terrifying fears.

In his disturbing and readable new book *The Genetic Age: Our perilous quest to edit life*, biologist and science historian Matthew Cobb tells the story of this field. Cobb’s last book, *The Idea of the Brain*, was a history of neuroscience, but this is a follow-up to 2015’s *Life’s Greatest Secret*, about cracking the genetic code.

Cobb keeps his focus on the applications of genetic engineering with the biggest impact, especially those that pose – or are perceived to pose – the greatest risk. In doing

Gene editing, exemplified by CRISPR technology, has elicited both hopes and fears

so, he calls attention to three areas of current research that are of particular concern.

The first is human germline editing, which involves tweaking a person’s DNA in such a way that the changes can be passed on to their descendants. The second is the concept of a gene drive, a “genetic chain reaction” that can spread a particular trait through a population and thus reshape an ecosystem. The third is gain-of-function research, in which microbiologists,

**“Many are too in love with clever technical solutions and don’t consider if the benefits are worth the risk”**

anxious to prevent pandemics, make more dangerous versions of pathogens to forecast how they might evolve in nature.

All three are claimed to have huge potential benefits. All three carry self-evident risks. Cobb is concerned, writing that “there were things that I discovered that made my blood run cold”. But he is aware there have been false alarms in the past. This is a technology that short-circuits our brains to some

extent, forcing us to reconsider assumptions such as “natural” things are “good” and “unnatural” things are “bad”. So, he wisely second-guesses himself, wondering if he is just overreacting because the technologies are new and strange.

That is where the history comes in. Cobb recalls previous controversies, including the 1990s scare about genetically modified “Frankenfoods”. With the benefit of hindsight, how bad were they?

He finds some reassurance: notably that geneticists are the only group of scientists to have imposed moratoria on their own work while risks were assessed. Furthermore, many concerns turned out to be largely baseless – genetically modified foods aren’t inherently bad for you – or could be handled by safety procedures and regulations.

However, Cobb also identifies a streak of hubris running through the field. Many practitioners are too in love with clever technical solutions and can’t resist implementing them, without considering if the benefits are worth the risk. He quotes a line from *Jurassic Park*: “Your scientists were so preoccupied with whether or not they could, they didn’t stop to think if they should.”

Cobb ends by raising the question of priorities. Is all this the best use of money? Proponents want to spend millions to save a handful of people from a single genetic disease, but that money could save millions of people from more common threats, such as dirty water. Sketchy plans to recreate extinct animals like mammoths will eat up resources that could be spent preserving threatened species.

Genetic engineering, it turns out, probably won’t end the world – but a lot of it might be a distracting waste of money. ■

Michael Marshall is a science writer based in Devon, UK

## Don't miss



### Watch

**The Rings of Power** takes us back to J.R.R. Tolkien’s Middle-earth, where Morfydd Clark plays a younger (but still ancient) Galadriel in Amazon’s bid to tell Sauron’s origin story. On Prime Video from 2am BST on 2 September.



### Read

**Taxi from Another Planet** records the unlikely conversations between astrobiologist Charles Cockell and taxi drivers about aliens and space exploration. So is Mars our plan B? Will we understand aliens? And what if we are alone? On sale from 30 August.



### Watch

**Artemis I** is NASA’s test of its Orion capsule, Space Launch System rocket and the ground systems at Kennedy Space Center. Register for free to see it launch en route for the moon at 1.33pm BST/8.33am EDT on 29 August.



ELLA MARU STUDIO/SCIENCE PHOTO LIBRARY

LEFT: NASA/MSFC; TOP: AMAZON STUDIOS

## The sci-fi column

**Outsider insights** Can crushing despair make great reading? *Face* and *The Sleepless* are two noir-inflected novels that compel with their bleak visions and great writing, both coming from distinct perspectives, says **Sally Adee**



Sally Adee is a technology and science writer based in London. Follow her on Twitter @sally\_adee



SHUTTERSTOCK/HALFPOINT

**The insomnia created by a pandemic turns out to have its upsides**

threads tied up. That said, it still qualifies as a ripping read. This was a rare glimpse into the mind of an author who has taken in all the worst aspects of social media hustle culture and extended them to their absurd, logical endpoint.

On her website, West identifies explicitly as a third-culture writer, elegant shorthand for someone who lives in one culture with parents from another that must make an uneasy space for the mix of the two. Such a perspective breeds the ability to patiently unstitch the fabric of a society that everyone else accepts – and expose its flaws.

While Manibo doesn't call himself a third-culture writer, he is an immigrant whose writing shows the same hard-won acumen and perspicacity that comes from an outsider perspective.

His keenly observed pandemic has clearly been crafted from the failed systemic responses to HIV and covid-19. Manibo has helped himself to the surfeit of cautionary tales and grimly funny corporate advantage-seeking that emerged in the wake of both.

His vision carries the weight of inevitable truth: once a couple of people stop needing to sleep, it won't be long before everyone else has to get in line and anyone who doesn't becomes obsolete.

Both authors offer compulsively readable entertainment delivered under a smog of crushing despair. As befits such noir-inflected writing, even when an ending is ostensibly happy, there is ambiguity. "The world is a very old place and it's seen its fair share of revolutionaries," says a character in *Face*. "But at the end of the day... well, look around." ■



**Books**  
**The Sleepless**  
**Victor Manibo**  
**Erewhon**

**Face**  
**Joma West**  
**Tordotcom**

**Sally also recommends...**

**Books**  
**Sleep Donation**  
**Karen Russell**  
**Vintage**

*A similar premise to The Sleepless, but a corporation makes money out of the pandemic by matching the sleepless with sleep donors.*

**Nod**  
**Adrian Barnes**  
**Bluemoose Books**

*Here, the insomnia kills. For everyone who loves this work of literary speculative fiction, there is someone fulminating over the main character.*

THE events in Victor Manibo's *The Sleepless* open 10 years after a pandemic. The initial panic is over and adjustments have settled into place. This outbreak didn't kill anyone. It just removed the ability to sleep from about 25 per cent of the population.

The upsides of this condition become apparent when it turns out that this insomnia doesn't exact a cost. Why would you sleep if you didn't have to?

Society in Joma West's *Face* has changed too, inexplicably and for the worse. Draconian social rules determine where on the social ladder you are born, but you can climb it if you master the art of "faceplay".

Faceplay consists not only of perfecting your identity, brand and beauty, but of showing mastery over your emotions. Your status rises and falls with your ability to dominate other people's brands, which you do by disturbing their emotional equilibrium with quick-witted and subtle jabs, while maintaining your own icy cool. "The best face is no face at all," one character

realises midway through the book.

Master the art and you can land a partner who was born higher up the ladder, and, in the final lunge of the social climb, engineer a baby that perfectly complements the family brand. Just never let your guard down.

In this Hobbesian, all-against-all nightmare, there is no such thing

**"The only way to understand what lies beneath is to experience it from the inside"**

as an ally, no safety to retreat to. It is a crushingly, abjectly lonely and stressful world.

The unusual structure of West's domestic dystopia is closer to literary sci-fi. Some scenes are rerun from the perspective of different characters, which works because no one gives anything away. The only way to understand what lies beneath is to experience it from the inside.

Unfortunately, *Face* ends much too abruptly and with too few of its

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Plus special guest

**Mhairi Aitken**

Ethics Research Fellow

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# The inner mind of plants

Are plants conscious? It is a controversial idea, but a small team of researchers are determined to find out, says **Natalie Lawrence**

**M**ANY people have seen the way a *Mimosa pudica* plant, also called the touch-me-not, folds its leaves when they are touched. Fewer know that if you put one into a sealed chamber with a dose of anaesthetic, it will eventually stop doing this, as though it has been knocked out or put to sleep.

The anaesthetic needn't be special. Diethyl ether, an old-school general anaesthetic, works well. Lidocaine, a local anaesthetic favoured by dentists, is also effective when applied at the roots. What's more, if you attach electrodes to the surface of the leaves at the same time, you will see that the waves of electrical activity that usually spread through the plant's tissues are suppressed. These effects aren't confined to *Mimosa pudica* – all plants are probably susceptible to anaesthesia, it is just that the effects are more dramatic in fast movers like *Mimosa* plants and Venus flytraps.

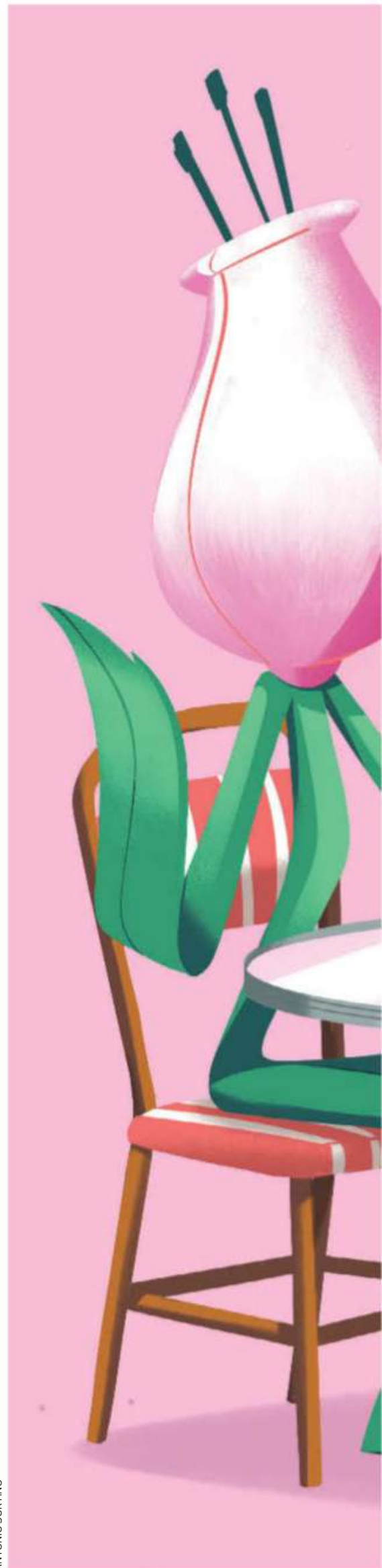
Paco Calvo at the University of Murcia in Spain has done this trick several times in front of audiences. It never fails to surprise onlookers, prompting them to ask the very questions he himself is trying to answer. If plants can be “put to sleep”, does this mean they exist in a state of awareness that is shut off by anaesthetics? Might we consider this state to be a kind of sentience, a subjective internal experience? If so, do plants have some form of consciousness? These are controversial ideas, but Calvo and a small group of plant behaviour researchers take them seriously.

Their findings so far, though tentative, could disrupt our understanding of consciousness – not to mention our attitudes towards plants.

Plants operate in ways that are difficult for us to perceive, so people have traditionally assumed they aren't doing very much. But more recently, researchers have found them to possess many sophisticated and surprising abilities. Plants can sense and react to more aspects of their environments than we can, and they maintain bustling social lives by communicating with each other above and below ground. They also interact with other species. Tomato plants, for example, release chemicals that encourage their caterpillar predators to indulge cannibalistic instincts and turn on each other. Bee orchids trick male bees into landing on their flowers by looking and smelling like exotic female bees, then load the duped insects with pollen. Evening primroses can “hear” their pollinators and fire up nectar production when exposed to their specific vibration frequencies. *Arabidopsis* plants can use the unique wavelength profiles of light reflected off nearby plants to tell relatives from non-relatives.

Some of these capabilities are evolved stock responses to particular situations – simple, hardwired reactions. Other behaviours, though, might be underpinned by some form of cognition. Distinguishing between the two in plants can be tricky. Nevertheless, Calvo and his colleague Miguel Segundo-Ortin at Utrecht

ANTONIO SORTINO





University in the Netherlands have identified three crucial factors that provide a litmus test. First, cognitive behaviour is flexible and dynamic, rather than being a repeated, knee-jerk reflex. Second, it is predictive: it indicates that the organism is anticipating changes in the environment. Finally, it is goal-directed: it causes a change in the environment or in the organism.

## Clever beans

Under this lens, we can see that a bee orchid tricking a male bee is just passively using the bee-catfishing equipment that has been honed through its evolutionary history. No cognition is needed. But a bean plant climbing up a pole? That might be a different story, says Calvo.

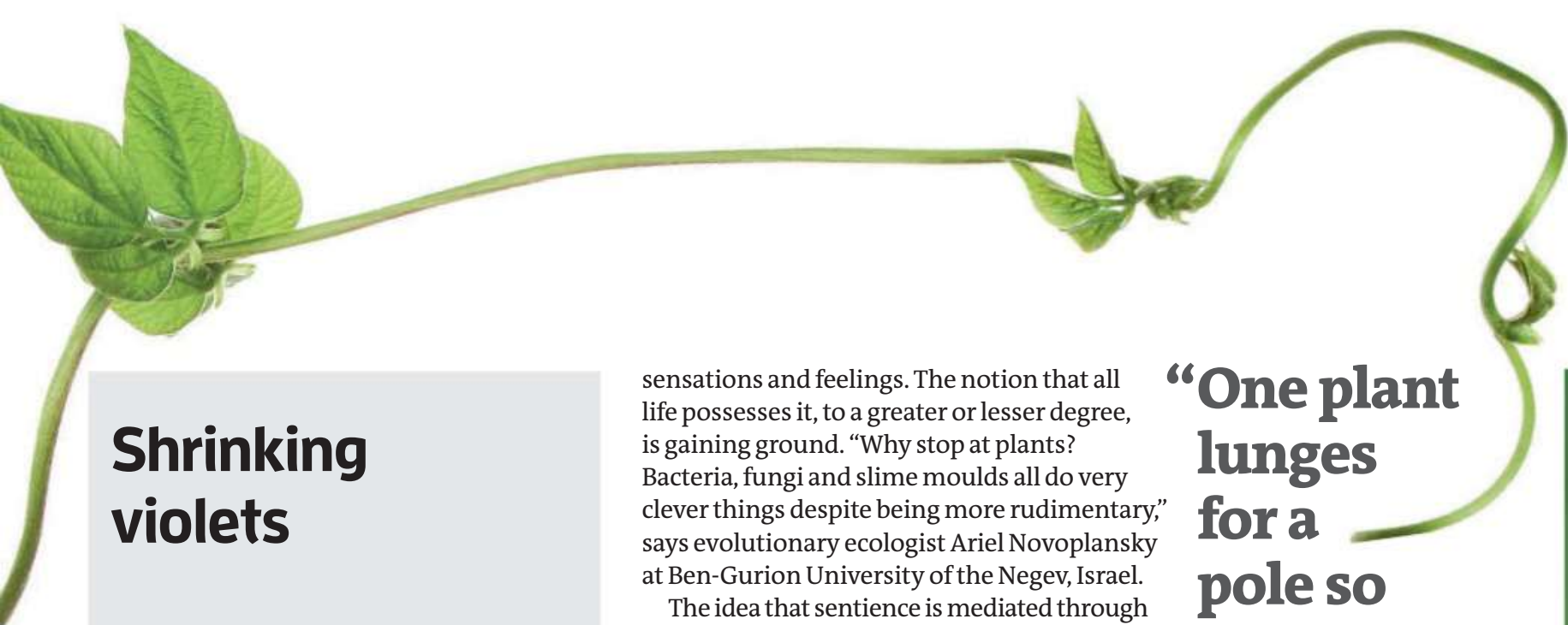
When beans search for a support, they make broad, circular sweeps of their surroundings, growing as they go. As they home in on a pole, some beans will suddenly lunge towards it like a drunken pub-goer taking a swing at someone. It is a rapid, directed change in behaviour. This suggests the plant isn't simply running a pre-programmed pole-seeking sequence. "It might even indicate that the bean 'knows' the pole is there," says Calvo. We need to know a lot more before we can be sure, however, he adds, and "we must be very careful not to assume too much".

Calvo believes that the first step in exploring the interior lives of plants is to look closely at their behaviour. He has spent many hours simply sitting and watching his favourite common bean plants (*Phaseolus vulgaris*) grow. "One way to tune in to plants is to slow down and get closer to their different timescales," he says.

At the Minimal Intelligence Laboratory (MINT Lab) at the University of Murcia, he and his colleagues take a more high-tech approach. Climbing beans are the star in their time-lapse photography set-ups. The researchers use images taken every minute to capture a plant's movements while monitoring its internal electrical signalling activity using electrodes and biosensors. These sequences have revealed how beans find supports: one particular plant in the lab lunges for the pole so rapidly that Calvo calls it Usain Bolt. The experiments also show that these behaviours are accompanied by spikes in electrical activity.

This kind of electrical signalling hints at a level of sentience throughout the whole tree of life, says Calvo.

Sentience is the capacity to experience ➤



## Shrinking violets

Could plants have personalities? This may seem far-fetched given that the idea of personality in non-human animals is still contested. Nevertheless, there is some research suggesting that individual plants have different and consistent behavioural tendencies, which could be the result of both genetic hardwiring and behavioural flexibility. *Mimosa pudica* plants, for example, can be bolder or more cautious in how long they keep their leaves folded in response to being touched. One study found that a significant part of the difference between the plants was down to individual disposition.

On a broader scale, plants that have been domesticated tend to be less canny and independent than their wild relatives. Wild vines, for example, can scour their surroundings for something to climb and rapidly scale up it. In contrast, domesticated vines flounder unless they have trellises or poles placed next to them. You might think of them as the pampered lapdogs of the plant world. "We have selected for docility, as we have with domestic animals," says Paco Calvo at the University of Murcia in Spain.

Occasionally, domesticated plants break out – they go feral. "They don't reverse the genetic changes of domestication, but they behave like tough guys," says Calvo. They start to grow in patterns similar to wild plants. Calvo argues that if individual plants have different personalities, it suggests that they have some kind of unique subjective awareness, some level of sentience (see main story).

sensations and feelings. The notion that all life possesses it, to a greater or lesser degree, is gaining ground. "Why stop at plants? Bacteria, fungi and slime moulds all do very clever things despite being more rudimentary," says evolutionary ecologist Ariel Novoplansky at Ben-Gurion University of the Negev, Israel.

The idea that sentience is mediated through electrical activity is generally acknowledged, given how our own brain and nervous system work. Plants don't have brains, but they produce a lot of electrical activity in their vascular tissues, the main transport system for moving nutrients and water around them, which extends from roots to leaves. They also use many of the signalling molecules seen in animals, such as GABA, acetylcholine and serotonin. So, while certainly not conclusive, these similarities do suggest that plants have the underlying architecture to support sentience.

But Calvo goes further. He believes that the flexible way in which plants grow, influenced by their surroundings and sensory information, indicates that they have unique, subjective experiences. This, together with the electrical signalling, hints that plants possess something that might be thought of as a sort of consciousness.

That may sound absurd, but it fits with a leading conception of consciousness called integrated information theory. In essence, this sees consciousness as the ability to integrate multiple aspects of experience into a whole, irrespective of the system, whether it be a brain, a computer chip – or a plant. The more integration, the greater the level of consciousness.

### Zap and zip

The MINT Lab team hopes to throw some light on how plants process information by adapting tools used to visualise activity in human brains. Purpose-built plant MRI or PET scanners would allow the researchers to map changes inside plant vascular systems and see what they are doing in real time. The primary method currently used to assess levels of consciousness in humans and other mammals is called "zap and zip". It uses magnetic fields to excite electrically conductive cells and then looks at the resulting activity – the complexity of the pattern giving a relative measure of consciousness. Calvo and his colleagues have suggested that a version of zap and zip adapted for plants might help reveal whether their

**"One plant lunges for a pole so rapidly we call it Usain Bolt"**

**Clockwise from left: bee orchids smell like female bees; *Mimosa* leaves fold when touched; the fast-moving Venus flytrap**

patterns of electrical activity underlie some kind of sentient experience.

While the MINT Lab is looking at electrical signalling, other plant behaviourists are taking different approaches. These include exploring the possibility that plants have personalities (see "Shrinking violets", left) and looking at how plants learn and remember. A team led by Monica Gagliano at Southern Cross University in Australia, for example, grew pea plants in Y-shaped mazes to see if they could be trained to grow towards a breeze, which seedlings would never do in the wild. When the researchers coupled airflow from a fan with a source of light, they found that the plants learned to grow towards the breeze even when the airflow was presented by itself – much as Pavlov's dogs learned to associate the sound of a bell with the imminent arrival of food. Although Calvo's team and others have been unable to replicate these findings, he doesn't see this as conclusive evidence that plants can't learn, just that it is difficult to probe the psychology of plants experimentally.

Some are more sceptical. Last year, Jon Mallatt at Washington State University and his colleagues argued that even if plants are





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capable of Pavlovian learning, the finding is irrelevant because it doesn't require consciousness. Their paper, titled "Debunking a myth: plant consciousness", also concluded that the electrical signalling in plants gives no indication of consciousness. "Complex information processing requires reciprocal signalling between cells," says Mallatt. "But no cellular back talk has yet been found in plants, only one-way signals."

Other critics see the idea of plant consciousness as little more than semantics. "There is neither evidence nor any scientific requirement for calling these coordinated reactions 'cognition' in plants," says Andreas Draguhn at Heidelberg University in Germany. Mike Blatt at the University of Glasgow, UK, has a similar view. "It's an interesting philosophical question, but not a very useful one for understanding plants, as everything they do can be explained physiologically," he says.

Some researchers are open to the idea that plants have basic sentience, but have some reservations about going beyond that based on current evidence. "We know plants are aware of their environment and of themselves and each other. We don't know if they are

## Growbots

**Plants interact with space in entirely different ways than animals do.**

**We have to traverse terrain, whereas they grow through space.**

**Taking a plant's perspective on movement is helping engineers develop new soft robots – machines made with malleable materials.**

**These plant-inspired robots are a little like giant, extruded balloons that expand outwards, growing like a bean stem exploring its surroundings. They could have many uses. They could navigate difficult terrains where traditional robots would flounder, such as the surface of Mars, and they can squeeze into tight spaces. They could even be used in brain surgery, entering the brain through its ventricles for delicate procedures.**

conscious," says Elizabeth Van Volkenburgh at the University of Washington. She suggests that philosophers and plant biologists should collaborate to agree a protocol to test the capabilities of plants.

Calvo welcomes these critiques. "Scientific rigour is founded on healthy scepticism," he says. And he is adamant that his team has made no unfounded claims. "We are focused on carefully understanding plant behaviour and working out experimentally just how much cognition and sentient capacity we need to explain it," he says.

Nobody doubts that we are a long way from understanding how plants experience the world. But where might research into plant cognition take us? Aside from motivating us to take better care of our houseplants, we might come to a new understanding of thought without neurons, and consciousness without a brain. At present, ideas about how our own minds operate focus almost exclusively on neural anatomy – we might need to rethink that. If the awareness at the centre of our conscious experience is something we share with all other living things, even plants, we might question whether humans are quite as special as we like to think.

Seeing things from the perspective of plants offers exciting practical possibilities too. Robotic designs inspired by plants have potential uses in space exploration and medicine (see "Growbots", left). Calvo is currently working with a Swiss company called Vivent using biosensors and machine learning to develop systems that detect plant stress and adjust their growing conditions in real time. Such systems could revolutionise farming and help ensure future food security. They might enable us to work with plants to face the challenges of the future, rather than regarding them as passive resources.

Perhaps we will also re-evaluate our ethical attitudes to plants, just as we are doing with non-human animals. "If plants have some degree of sentience, can we justify our treatment of them in agriculture, logging and all the other ways we exploit them?" says Calvo.

All of this could stem from a radically different perspective on plants. First, though, we must work out how to see them clearly. ■



Natalie Lawrence is a writer based in London, UK, and co-author of *Planta Sapiens: Unmasking plant intelligence* with Paco Calvo

# Want a glimpse of baby's future?

If you were offered the chance to unravel your child's whole genome just after birth to see what may lie in the years to come, would you say yes? In 2015, a groundbreaking trial asked parents to do exactly that. Now, seven years down the line, **Katharine Gammon** discovers the consequences



**A**LYSSA CARTER had just given birth when a doctor asked if she would like to find out more about her baby's genes. With a few spots of blood, researchers could sequence her son's whole genome. She would receive a report that predicted various aspects of her baby's future health. "I eagerly signed up," says Carter. But although she had been briefed on the possible outcomes, it hadn't occurred to her that there might be bad news. When she saw the results, her stomach lurched.

In the 21 years since whole-genome sequencing was first applied to humans, it has become a powerful tool – instrumental in tracking disease outbreaks and diagnosing mysterious conditions. But as the technology evolved, so too did an extraordinary idea. What would happen if we knew the intimate details of our entire genome from birth?

The implications are a minefield, said ethicists. Who will have access to the data? Will it be useful? How will it affect parents and children over the course of their lives? The benefits could be worth the risk, said others. What if we could spot diseases before they took hold or help someone avoid a risky behaviour? Could it even mean the difference between life and death? The way to find out was to run a unique trial. That trial, in which Carter's child is a participant, is now seven years old and is finally starting to provide answers to these fundamental questions.

The human genome contains about 25,000 genes, and the first (almost) complete sequence of it was achieved in 2001, costing about \$1 billion. Last year, it was completed for real, with the additional sequencing of 2000 genes that had been hard to place. Back in 2001, Francis Collins, then director of the US National Human Genome Research Institute in Maryland, predicted that it would be feasible within 20 years to use this type of genetic data to produce a "kind of report card analysis" for every newborn baby's health.

Before this could happen, though, researchers spent decades exploring the use of whole-genome sequencing in adults. As the technology dropped in price, they slowly revealed the medical, behavioural and economic impacts of incorporating such sequencing into everyday medicine. Among the many projects designed to do this was MedSeq, which began in 2012 and was the first study to examine the use of whole-genome sequencing in people with suspected genetic cardiac disease. It also looked at people who were in good health with no family history that

suggested they were at risk of a genetic disease.

One of the most surprising outcomes of this work was the discovery that a significant percentage of the latter group carry deleterious mutations – gene variants that increase a person's susceptibility to a certain condition. "We found 20 per cent of healthy adults carrying something that might put them at risk of a disease," says Robert Green at Brigham and Women's Hospital in Boston, Massachusetts, who led the project.

It was then that he wondered whether it might be time to put Collins's prediction into action. "We thought, we want to sequence people as soon as possible in life," he says, rather than wait until the diseases may have already started to develop.

The UK already routinely screens babies for nine rare conditions that can affect long-term health by looking for biomarkers in a few drops of blood from the newborn's heel. States in the US screen for at least 29 conditions.

Adding whole-genome sequencing to the mix could allow doctors to potentially identify hundreds more conditions that might affect a child's life. But testing this idea hasn't been easy. For a start, it wasn't clear what conditions should be included, how results might be interpreted and how knowing this information might affect the parents or long-term health of a baby. Only two things were certain: speculating wasn't going to provide any answers and private companies weren't going to wait to start offering the service.

## Predicting the future

Green felt a scientific responsibility to begin a trial sequencing the genes of newborn babies, so that any challenges could be mitigated and understood before whole-genome sequencing was launched onto an unsuspecting public. "We wanted to do it really well and understand the process," he says.

First, he and his team deliberated on which conditions to include. With a whole genetic landscape at their fingertips, there needed to be some ground rules. They decided that each condition had to have solid evidence of how genes affected it. They also questioned whether to return results related to adult-onset conditions – problems that couldn't be treated in childhood, such as Alzheimer's.

Eventually, they focused on 954 genes that were related to childhood diseases and included a limited list of adult-onset conditions in the study. It meant that some ➤

# Should you get your whole genome sequenced?

of the results could indicate a parent was at risk, too. “Our logic was that there isn’t much better for the baby than saving the life of the parent,” says Green. The trial, called BabySeq, started enrolling up to 500 participants in 2015.

There were a few teething problems. Preliminary surveys suggested that 70 to 80 per cent of people would want to join. But when the team actually went to maternity wards to enrol volunteers, only 7 per cent of the parents they asked signed up.

Another issue was figuring out how to break bad news to parents whose results showed their newborn was at risk of a severe disease. Carter was a case in point. A counsellor shared that her son had a rare disease-causing variant of the *ELN* gene. The variant is associated with supralvalvular aortic stenosis, which is characterised by a narrowing of the aorta. It can lead to heart failure. However, severity differs and not all those with the variant will go on to develop the disease.

## Families under the microscope

Carter wasn’t emotionally prepared for the “word salad” of information about her son’s potential condition and for what it all meant. “We have to navigate medical care for something that exists in theory, that could be a big deal, but might not happen,” she says. More tests showed that her baby had inherited the disease-causing variant from his father. How would this information affect them all?

That was exactly what BabySeq researchers wanted to explore. Their study involved getting parents of 325 newborns to complete surveys when they enrolled in the trial, immediately after their child’s results were disclosed, three months later and 10 months later. Half of the children received standard newborn screening plus a family history report, the rest received standard newborn screening plus a report based on whole-genome sequencing.

The surveys examined the parent-child relationship, the parent-parent relationship and the parents’ psychological distress. An analysis of the results, published last year, found no long-term negative psychological harm in a parent having knowledge about their child’s genome, even in families where the sequencing found an increased risk for a disease. Perhaps surprisingly, parents of babies who had received genetic sequencing scored lower on a test of self-blame for passing potentially harmful genes onto their baby.

There are limitations, the researchers say:

**Private companies already offer whole-genome sequencing for adults. The price has come crashing down, falling from thousands of pounds to just a few hundred in the past five years. But is it worth it and can it really tell you anything that your family medical history can’t?**

**To find out, a 2017 study recruited nine primary care doctors and 100 of their patients who had no history of cardiovascular disease or diabetes and were deemed generally healthy. The aim was to see how whole-genome sequencing affected the health of the patients. Half of them received a family history report and whole-genome sequencing; the rest received a family history report alone. The sequencing revealed a high rate of increased risk for rare, monogenic diseases – conditions caused by a variation in a single gene. Yet the participants themselves had no sign of the illnesses their genes showed. It turns out, markers for genetic disease are far more common than expected.**

**Most of the people who received genetic information didn’t panic over the results, and the doctors in the study generally advised them to do the right things (as judged by an independent panel of geneticists). Six months later, the people who received genetic results were more**

**likely to have made positive changes to their health, when compared with the control group. But the genome sequencing was more expensive than a family history and had no significant impact on health outcomes during the study period.**

**“Whole-genome sequencing can offer up a lot of information for adults,” says John Gorzynski at Stanford University in California, which may make them change their behaviour in a positive way. But there are things that we can do now to make our lives healthier, he says – and an awful lot of them we know we should do without having to sequence our genomes.**

The cost of sequencing a whole genome has plummeted in recent years to just a few hundred pounds



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it could be that the parents who agreed to participate are already interested in the research outcomes, or that the results only reflect a small portion of the population. A second project, BabySeq2, is now enrolling a more diverse set of families across the US.

BabySeq’s first cohort was comprised of babies born in intensive care and babies without any overt health conditions. Genetic sequencing of ill babies has a long history of having a positive impact on health. And as the technology is getting faster and cheaper, the impacts are even greater. For instance, in 2018, doctors were able to sequence a child’s genome and diagnose a disease in 7 hours and 18 minutes – a world record for fastest genetic diagnosis.

John Gorzynski at Stanford University in California, part of the team that carried out the

rapid diagnosis, says that babies used to spend months in hospital if they had a condition that couldn’t be explained. Now that they can have their genomes sequenced faster, it means fewer tests, less time in hospital and a speedier treatment for genetic-based illnesses.

But while genetically screening sick babies has obvious benefits, the consequences of screening healthy babies has been less clear until now. BabySeq’s latest results, posted earlier this year ahead of formal publication, show that 18 per cent of 159 babies with no current medical problems who had their genome sequenced at birth had a mutation for a childhood-onset or adult-onset genetic condition. All of the conditions had available clinical interventions. In eight cases, the results prompted screening for at-risk family members, too. For instance, the maternal

## Knowing your genes from birth could influence behaviour

grandfather of a child in the study had been previously diagnosed with a heart condition. The baby was shown to carry the variant that predisposes them to the same heart condition. Consequently, the child's mother now has routine echocardiography.

## Changing behaviour

Gorzynski says it is likely that a lot of children and adults will have their genome sequenced in the next decade (see “Should you get your whole genome sequenced?”, left). Indeed, the UK government recently launched its own newborn genome screening project, enrolling 200,000 newborns to explore whether it accelerates diagnoses and access to treatment. “If we can know more about a person's genome in terms of how it may affect their health, I think that is really beneficial,” says Gorzynski.

Not everyone agrees, however. Josephine Johnston at the Hastings Center, a think tank in Garrison, New York, has published a report on the ethics of newborn genome screening, listing some of the problems. One is that sequencing the entire genome has the potential to give results that aren't significant or actionable, causing worry without any pay-off. And although BabySeq has been running for a while now, there is limited understanding of how such early knowledge of your genes affects your life over the long term.

We know from a 2019 study, for instance, that being given genetic information can change behaviour. When people were told they had a genetic propensity for either obesity or lower exercise capacity, it altered the way their body responded to a meal and exercise (even though the result was, in fact, fake). And of course, when screening newborns, you are making these decisions on behalf of an individual who, as an adult, may not want to know about them. A paper co-authored by Green, published last year, found that more than a third of people whose genetic information showed a disease-causing variant with an actionable outcome chose not to receive the information.

David Curtis at the University College London Genetics Institute says that privacy and consent are his biggest concerns. An individual's medical information is private, he says. If a child is sick and must be treated without their consent, the parents may get information about the child's health. But it isn't the case that our parents have the right



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## “Would you want to know whether your baby is predisposed to having a high IQ?”

to total knowledge about our health, he says. “We're talking about basically subjecting all members of society to a medical investigation that will yield huge amounts of private information, which will be somewhere, available to whoever, without the individual's consent.” It isn't clear to Curtis who will hold the genetic information, how it will be tied to public health records or how often each genetic risk leads to actual disease. “The potential benefits are absolutely minuscule, and we can deliver them in other ways,” he says.

BabySeq's data is held by a lab in Massachusetts and parents have consented to its use for research, says Green. “The whole purpose of BabySeq is to understand precisely what are the benefits, harms and costs of implementing this.”

It is also unclear how a baby's genetic data could be used in the future, adds Curtis. Indeed, although researchers are currently focused on the medical outcomes of newborn genetic screening, it may be possible to correlate the data with other outcomes in the future. Would you want to know whether your baby is predisposed to having a high IQ or excellent sporting ability? It is too early for this kind of prediction, but research is progressing in these areas. A 2018 study of 1.1 million people found correlations between certain genes and educational attainment, for instance.

These are all questions that need to be explored. For Carter, though, the information from her newborn's sequencing was ultimately a good thing. Her son is now 6 years old and is assessed every six months. He is doing great, she says: no symptoms have developed. There are little things she pays more attention to than she would have – she would immediately go to the doctor if he had any chest pain, for instance, however minor.

Carter hopes that genome sequencing will be more accepted in the future. “I would much rather know than not know. I think of the pain and suffering information like this could help ease,” she says. “There's power in knowledge.” ■



Katharine Gammon is a science journalist based in California



JANELLE BARONE

# Into the singularity

To explain what happens at the centre of a black hole and find a unified theory of everything, physicist **Vlatko Vedral** says we need to rethink time in quantum mechanics

**I** WOULD like to take you with me, just for a minute or two, on a journey through space and time. We are minding our own business, watching the stars and galaxies zip by, when, suddenly, an invisible force draws us in. The closer we get to its source, the faster we move. Eventually, we are moving so quickly that time slows. We become extremely heavy and nothing can stop us – we are hurtling towards a black hole.

On our approach, we start to see streaks of light curving around a dark centre. This is the event horizon, the point beyond which gravity is so great that nothing, not even light, can escape.

But our journey must end here. Putting aside the torture it would place on our bodies to go further, we can't even imagine what lies beyond this point. At the centre of a black hole, our best description of gravity, the general theory of relativity, breaks down and our other great theory of nature, quantum mechanics, must kick in. We have reached a place where our two best ways to describe the universe – relativity on the larger scale, quantum mechanics on the very small – come together in some way we don't yet understand. Trying to unify these remains one of our greatest challenges.

However, there are now glimmers of hope. Recently, I have been developing an idea that might get us somewhere by making quantum mechanics more like general relativity. With the help of some experiments, it could lead us to the centre of our black hole, and to a unified theory at last.

In physics today, we have two pictures that don't match up. First is general relativity, Albert Einstein's set of equations that describe the way classical objects are affected by gravity. It sets out the three dimensions of space and the fourth dimension of time as part of the same entity, woven together in the fabric of space-time. That works extremely well, to a point. It is excellent at describing the way space-time bends around large masses, the way time slows down when objects move close to the speed of light, and anything that concerns the dynamics of things larger than an individual particle.

But the fundamental force of gravity doesn't fit into quantum mechanics, our best description of the very small. Atoms and subatomic particles seem to follow a totally different rule book. They are governed by the other three fundamental forces of nature, the electromagnetic force and the strong and weak nuclear forces. Particles can appear to be in two places at once. They can be entangled, with information seemingly passing between them instantaneously, even when they are far away from each other. The quantum world is also characterised by a strange fuzziness – the uncertainty principle that says the more we know about a particle's position, the less we can be sure of its momentum. If this were the case in general relativity, then you would only be able to know where your car is or how fast it is going, never both.

Both theories have been remarkably successful in their own domains. But the

problems occur when they are applied, at the same time, to a situation where both should matter, like the centre of a black hole. We know black holes, which were predicted by general relativity, exist. But since they involve a humongous gravitational field packed into a quantum-sized region of space, we have no way of describing what happens in their centres.

This leaves a huge question: how to marry the physics of the very big and the very small into one coherent theory of everything? This question is at the heart of the search for a single mathematical framework that describes the whole universe, and there is no shortage of people trying to find an answer.

It would be impossible to mention every individual idea that attempts to unite physics, but I like to consider them in groups. The first I think of as theories of quantum gravity. These take ideas from general relativity – like space-time, for example – and tweak them to fit quantum mechanics. Among the most popular of these is an idea that treats gravity like any other field, such as the electromagnetic field. In this theory, gravity is thought to be mediated by a hypothetical particle called a graviton, similar to the photons that mediate electromagnetic interactions. Gravitons, however, would interact so weakly that directly detecting one is nigh-on impossible.

In other approaches, space and time become discrete, meaning they can only exist in finite chunks – the same way that the energy levels in an atom are discrete, or quantised. An example of these is loop quantum gravity, in which these quantised chunks of space-time are tiny loops.

Then there are approaches that favour gravity over quantum physics. In the 1970s and 80s, for instance, Lajos Diósi and Roger Penrose speculated that quantum physics won't endure beyond some basic strength of gravity, at which point the so-called quantum wave function that encapsulates quantum properties collapses. Classical gravity, according to this view, ultimately wins. Other such approaches are keen to understand quantum physics geometrically, to cast it in a form that is mathematically closer to general relativity, like thinking of quantum superpositions as analogous to the curvature of space-time in relativity.

Finally, there are advocates for a more fundamental theory from which general relativity and quantum mechanics both evolve. String theory, which seeks to rewrite ➤

**“In some cases, particles seem to be affected by events that happen in their future”**

our understanding of what everything is made of, is the most prominent of these. Instead of electrons and quarks being fundamental, string theory claims everything is made of unbelievably tiny, vibrating “strings”, and that those vibrations produce effects that we interpret as the particles we see. Unfortunately, string theory also requires a host of other entities – such as multiple extra dimensions – that are well beyond our experimental reach.

It is fair to say that all of our approaches to unify quantum physics and gravity have failed so far, due to both the lack of mathematically consistent descriptions and the absence of experimental tests. This is a problem.

But what if we look at things another way? Instead of taking ideas from general relativity and moulding them to fit into quantum mechanics, I think we need to change the way we think of time in quantum mechanics. What if, to make quantum mechanics more compatible with general relativity, we treat space and time in the quantum world as we do in space-time – namely, on an equal footing?

In relativity, time is interwoven with space. It can bend and stretch, depending on the speed or the gravity involved. This is a far cry from the way most physicists talk about time in quantum mechanics, where it is a fixed, separate entity, a series of steps through which interactions evolve and nothing more. In traditional quantum mechanics, time is only inferred from looking at other observable quantities, such as the hands of a clock.

This is reflected in the way we tackle equations in quantum mechanics – how we, for example, describe the position in space of a qubit, a quantum mechanical alternative to the classical bit in computing, which can exist in superpositions of several states at once. We describe the qubit over time using a bit of mathematics called the Schrödinger equation, which describes the strange and equivocal behaviour of quantum objects and allows you to reliably calculate the odds of which of that object’s properties, such as its location, you will see when we take a measurement of it.

## Entangled in time

About 10 years ago, I began to consider an alternative to the Schrödinger equation. I read about some experiments showing that quantum entanglement – the superstrong link between the states of two quantum particles

after they have interacted – can exist between not just objects in space, but also between the states of the same object at two different times. This means that, in some cases, particles seem to be affected by events that happen in their future. This is a strange idea to get your head around, undoubtedly. But it got me thinking, if particles can be entangled over time, then perhaps in quantum mechanics, time isn’t the steady, outside ticking clock we think it is.

After this realisation, I wasn’t entirely clear how to proceed. But, for the past decade, along with my colleagues Joe Fitzsimons at the Singapore University of Technology and Jonathan Jones at the University of Oxford, I have developed an alternative mathematical approach, one with profound implications.

Instead of describing the behaviour of a quantum object in space at one specific time, we describe the behaviour of quantum objects across all space-time at once. When making calculations about how a particle should interact, for example, we write down all the possible outcomes at all the possible points in space and every instance of time, instead of just at one instance of time as is normally done with the Schrödinger equation. The fundamental dynamics are the same – particles are still governed by the three fundamental



**Uniting physics  
could help us  
decipher black holes**



SHUTTERSTOCK/JURIK PETER

In one experiment, Marco Genovese at the National Institute of Metrology Research in Turin, Italy, and his group looked at photons and their polarisation, which is the way that the electric field oscillates as a photon moves through space. In another experiment, published in February 2021, Jones used a quantum property of particles called nuclear spin – which is driven by an external magnetic field – to illustrate the same idea. The crux of both experiments is to measure the qubits at multiple times and calculate the quantum state we are probing, be it nuclear spin or polarisation, across both space and time, then test this against our predictions.

What these experiments have demonstrated is that anything that can be calculated using the standard approach to quantum physics can also be calculated – just as easily – using our space-time version. Our description of quantum states is a perfectly valid alternative to that of standard quantum mechanics. But because it shares a description of time with general relativity, it is a step towards a unifying theory.

What we haven't shown yet is that our approach has advantages over the standard one. To do this, we need to zoom in to the very smallest of scales. Let us go back to our journey towards the singularity at the centre of a black hole, where general relativity breaks down. The breakdown is intimately related to the fact that general relativity equations blow up when we allow space and time to be arbitrarily small around the black hole centre, leading to an infinite quantity called a singularity. But when we apply our new way of thinking about space-time in quantum mechanics, we can incorporate an extra degree of fuzziness that will save us from these singularities.

## Quantum time travel

Just like the uncertainty that exists in quantum theory between a particle's position and momentum, there may also be an uncertainty between space and time. If this is true, it means that at the centre of a black hole, the regions of space-time would be so small that space and time can no longer be discriminated from one another.

We can – in principle – probe that experimentally, too. The test would be similar to how we check the uncertainty relations between the position and momentum of a single particle, but we would now be testing the uncertainty between space and time. If

we measure a distance between two events in space more precisely, their temporal separation becomes more uncertain. We don't know if this is the way nature is, but our approach can certainly handle it in case it turns out to be true. Current experiments don't seem to have enough resolution to test space and time at these minute scales. However, the technology required to do so is progressing rapidly.

If we turn out to be right, then the centre of a black hole would be one place in which space and time could no longer be discriminated from one another. A singularity occurs at the point where both space and time contract to zero. But a quantum uncertainty in space-time would prevent something like this from happening, since both space and time couldn't have the precise value of zero at the same time. Getting over this stumbling block would be a breakthrough towards being able to unite general relativity and quantum mechanics.

As if that isn't mind-boggling enough, there is an unexpected implication of all of this, too: quantum time travel. Closed time-like loops are theoretical loops created when space-time curves so much that it closes in on itself – a route, it might seem, to the past. But until now, although they appear to make sense in relativity, physicists have dismissed time-like loops, because they are prohibited by quantum mechanics.

Think about an entangled pair of particles, connected through some interaction so that a measurement on one immediately affects the other. If one of the two particles goes through a time-like loop, this trip back in time creates two copies of that particle, one younger and one older. Each of the two copies ought to be maximally entangled to the other particle, the one that didn't go through the time loop, which isn't allowed in conventional quantum physics. But if we use our method to describe the situation, then the younger and older versions of the particle are simply entangled in time, something that is perfectly possible in our quantum space-time.

All of which means that, with our new theory of everything, not only could we finally finish our imaginary journey into a black hole, we might just find a route back in time as well. ■



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forces. But instead of, for instance, describing a particle's position over space at one point in time, we describe it over space-time.

Just as time is relative in general relativity, meaning it depends on the observer, time becomes relative in this description of quantum mechanics, too. It is no longer a fixed, separate entity. It depends on the observer. What this means is that when you are looking at two descriptions of a position in space-time, for example, it isn't always possible to say whether one happened before the other. This ambiguity doesn't exist in standard quantum mechanics, where each of two events are in a clear relationship with one another as far as any observer is concerned.

In our description, which we first introduced in a paper in 2015, space-time is an entangled web of quantum-correlated events all given in advance. This is important because this new way of thinking about quantum mechanics lends itself to unifying quantum theory with general relativity, in the sense that both now have a way of describing time that matches up.

Now, 10 years since I began working on this idea, my colleagues and I have started to test it. We have performed experiments with two types of qubits to illustrate that our approach works.

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\*Based on results of candidates entered through Pembrokeshire College (68239/68298) with AQA, Edexcel, OCR in summer 2022 exam series.

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from her friends. The AV1 provides her with purpose for the day, and allows her to get the support she needs from a teacher and her classmates."

SEND Department, Broadland High Ormiston Academy, Norfolk, said: "This is the next best solution to face-to-face teaching."

AV1



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Private Tuition Specialists are PATOSS, BDA and SFE registered. \*Dyslexia statistics (gov.uk, 2017)

## Puzzles

Try our crossword, quick quiz and logic puzzle **p53**

## Almost the last word

What stops us from processing weeds into edible food? **p54**

## Tom Gauld for New Scientist

A cartoonist's take on the world **p55**

## Feedback

Mice on the brain and snakes with legs: the week in weird **p56**

## Twisteddoodles for New Scientist

Picturing the lighter side of life **p56**

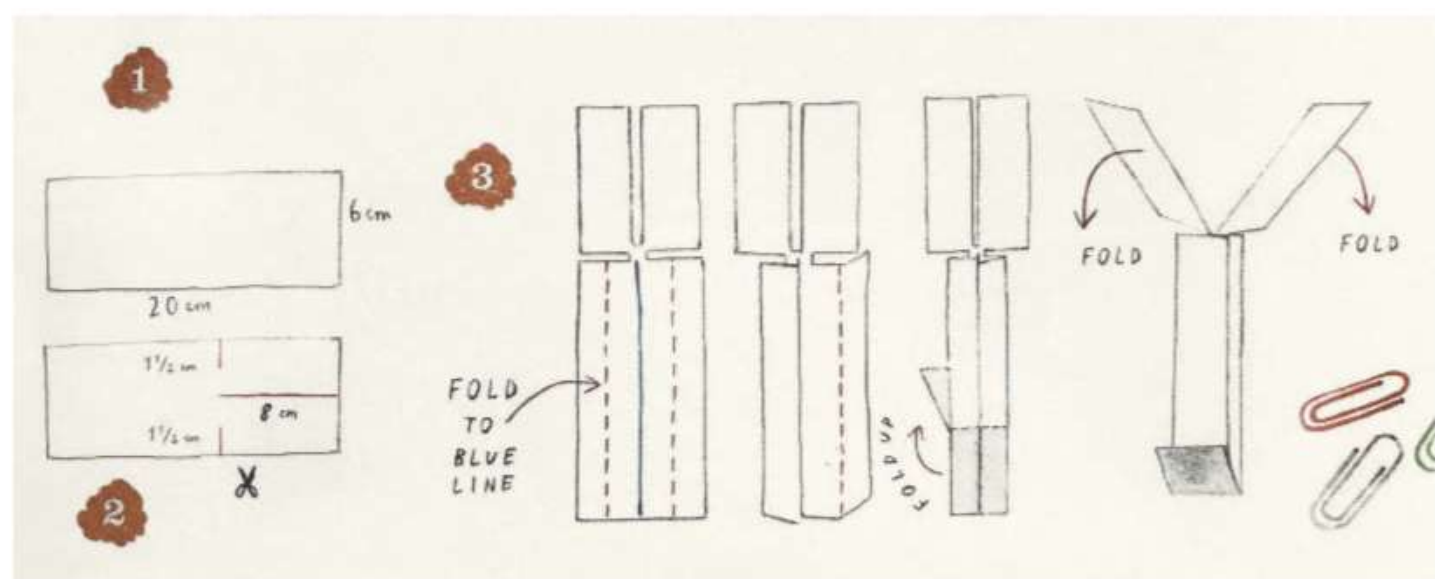
## Science with children

# Spinning out

Most children can fold a paper plane, but **Alom Shaha** prefers paper helicopters – and they are better for experimenting with



Alom Shaha is a physics teacher at a comprehensive school, and author of books including *Mr Shaha's Marvellous Machines*. Follow him @alomshaha



## What you need

**A sheet of A4 paper**

**Scissors**

**A ruler (optional)**

**One or more paper clips (optional)**

THERE is a deep satisfaction to be had from making and throwing a paper plane. From the number I have had fly across my classrooms, I have been able to ascertain that most children over the age of 11 know how to make one, albeit of varying quality.

I wouldn't be doing my job properly if I didn't encourage further experiments. They might investigate the factors that contribute to a good flight, and find out for themselves the importance of precise folding and the exact position of the centre of mass. Apparently, real scientists also do this sort of thing and get their work published in the *Journal of Fluid Dynamics*.

I also like to show my students how to make paper helicopters, because far fewer people seem to know about these and they are just as delightful to play with.

Start, as shown in diagram 1, above, by cutting an A4 piece of paper into a rectangular strip about 6 centimetres wide and

20 centimetres long. Make three cuts in the paper, as shown by the red lines in diagram 2, above left.

Fold the paper along the dotted lines shown in diagram 3, above. If you have one, attach a paper clip to hold the bottom flap closed. Bend the "blades" in opposite directions, as shown in the final image, then hold the helicopter up by its stem and drop it.

The thing that surprises most people who haven't seen this before, is the fact that the helicopter starts spinning by itself. You can explain to the child, as you do the experiment, that when you drop the helicopter, air is pushed into the folds where the blades meet the stem. The asymmetric structure of the helicopter, with each blade attached to half the stem on opposite sides, means that air pushes each side of the stem in opposing directions but along parallel lines, producing what is known as a couple.

This makes the stem rotate, a bit like when you spin a coin on

its edge by pushing on both sides at the same time.

The blades are pushed upwards by the air as the helicopter falls, so that they aren't horizontal. This means that, as they spin, they experience a lift force – like when you hold your hand out of a moving car window at an angle. This reduces the effect of gravity on the helicopter and causes it to fall more slowly than it would if it weren't spinning.

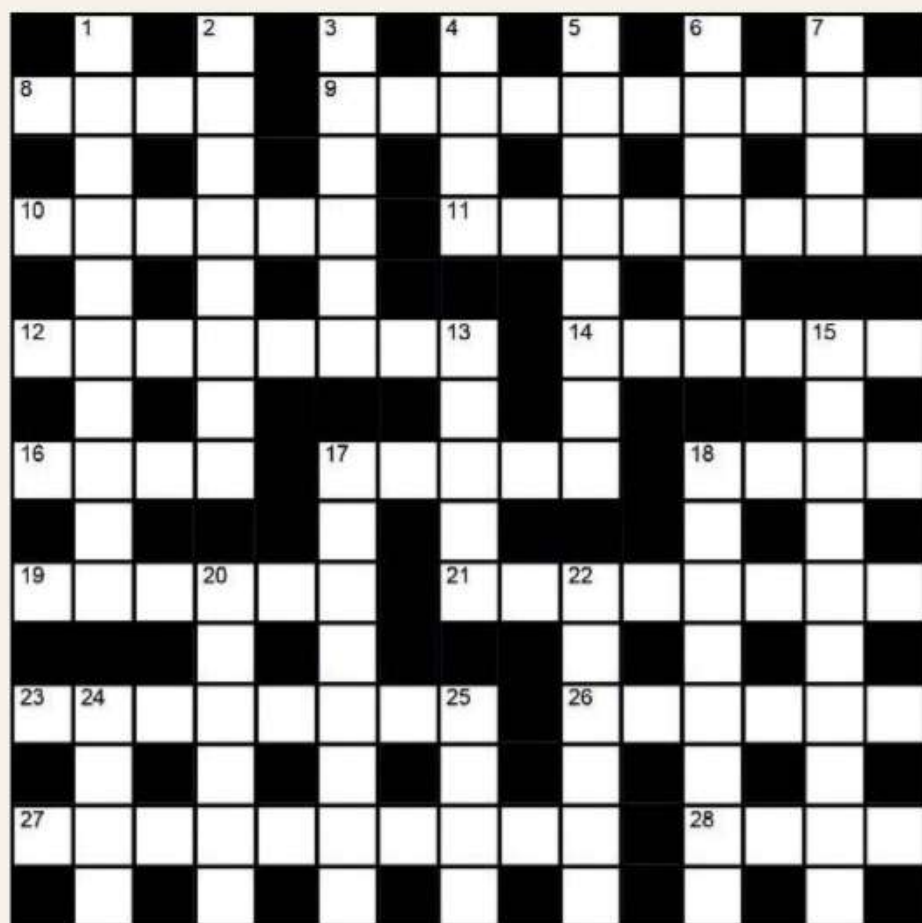
Show the child you are with that their helicopter should fall in pretty much the same way every time they drop it. This reliability makes it ideal for doing some experiments. What do you think will happen to how fast it spins and falls if you attach one or more paper clips to the bottom? Why? How could you make it spin in the opposite direction? How could you make it fall faster or slower? ■

## Next week

The science of cooking

**These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)**

## Quick crossword #115 Set by Richard Smyth



**Scribble zone**

Answers and the next cryptic crossword next week

### ACROSS

- 8 Refractive device (4)
- 9 Cancer specialist (10)
- 10 Otto \_\_\_\_, Austrian-British nuclear physicist (6)
- 11 Fermion denoted by  $\nu$  (8)
- 12 Outermost cell layer formed in the early development of an embryo (8)
- 14 Perennial plant noted for its colourful and aromatic flowers (6)
- 16 Active volcano on Sicily (4)
- 17 Auricle (5)
- 18 Ultimate (4)
- 19 Flightless parrot of New Zealand (6)
- 21 Termite-eating mammal of east and southern Africa (8)
- 23 Wood preservative (8)
- 26 Exhalation (6)
- 27 Able to eat many things (10)
- 28 Embolus (4)

### DOWN

- 1 Red earthenware ceramic (10)
- 2 Genus of internal parasites (8)
- 3 Songbird of North America (6)
- 4 (Medical) examination (4)
- 5 Eye disease (8)
- 6 Fly \_\_\_\_, toadstool, *Amanita muscaria* (6)
- 7 \_\_\_\_ Council, body governing the names of pharmaceuticals in the US (4)
- 13 Japanese culture of comics and animation (5)
- 15 Reduction of heat transfer (10)
- 17 Procedure; etiquette (8)
- 18 Ernest \_\_\_\_, inventor of the cyclotron (8)
- 20 Relating to a fundamental particle (6)
- 22 Simple carbohydrate,  $C_5H_{10}O_5$  (6)
- 24 Slope (4)
- 25 Alkene with a hydroxyl group attached (4)

## Quick quiz #166

- 1 How many ossicle bones are there in each inner ear of humans?
- 2 The dwarf planet Ceres circles the sun between the orbits of which two planets in our solar system?
- 3 *Rhacophorus nigropalmatus* is a frog species named after which naturalist?
- 4 In what year was the Analytical Engine, a mechanical computer, first described?
- 5 In which modern-day country was the ancient Badarian culture situated?

Answers on page 55

## Puzzle

set by Katie Steckles  
**#182 Riff raffle**

Quadrucon is an event that is themed around four-digit numbers, so when the organisers decided to hold a charity raffle, it made sense for all the ticket numbers to have four digits. Tickets were printed in one long roll, beginning with 1001 at the start of the roll and numbered consecutively from there. Tickets were then sold to delegates in strips of a fixed length.

Once everyone had bought a strip of tickets, event organiser Ivy Tetraglyph took to the microphone and announced that the first winning ticket number was 2772.

"That's a palindrome!" said somebody. And by strange coincidence, it turned out that all the other winning numbers were palindromic too.

As the winners filed forwards to claim their prize of a digital clock, the Quadrucon team noticed an interesting pattern: every winning ticket was the smallest number on the strip it was attached to. In fact that is the only place where palindromic numbers could have been.

What length were the strips of tickets sold in?

Solution next week



Our crosswords are now solvable online  
[newscientist.com/crosswords](http://newscientist.com/crosswords)

## Weedy diet

**What stops us from processing weeds into tasty and edible food?**

**Faith Anstey**

*Dalguise, Perth and Kinross, UK*  
Because then they wouldn't be weeds any more – they would be vegetables. As Ralph Waldo Emerson said: "What is a weed? A plant whose virtues have not yet been discovered."

**Bryn Glover**

*Kirkby Malzeard, North Yorkshire, UK*  
Just about every plant cultivated for human consumption began life as a "weed".

As someone who often forages for wild morsels, my experience is that few are worth the effort. Most are tough, stringy or bitter, and given the relative ease with which anyone can grow simple salad vegetables, the effort involved in foraging is rarely worthwhile. There are a few exceptions, such as young dandelion leaves or hawthorn leaves.

**"As someone who often forages for wild morsels, I find that few are worth the effort. Most are tough, stringy or bitter"**

**Richard Swifte**

*Darmstadt, Germany*  
Nothing stops us eating weeds other than commercial considerations. In fact, humans have been doing this for thousands of years, ever since we developed farming. "Weed" is simply the word we use for plants that we don't want in our gardens or agricultural fields.

Early hunter-gatherer humans, as well as our primate ancestors, ate suitable (i.e. tasty and non-poisonous) fruit, leaves and roots taken directly from nature. Farming then enabled us to start selectively breeding such plants to increase their edible output, so today we have a range of food



RYAN BROWNE/SHUTTERSTOCK

## This week's new questions

**By a hair** At the recent Commonwealth Games, I was struck by how many runners with long hair had tied it in a ponytail. When fractions of a second can decide a race, surely looser hair is a drag? *Helen Read, Farnham Common, Buckinghamshire, UK*

**Hitting the spot** What happens to a photon after it hits the retina of my eye? *Adam Eri, Vienna, Austria*

plants that often appear very different from their wild ancestors.

There is, however, a niche market for a variety of wild plants. One is the dandelion, normally considered a weed. But this plant is edible and nutritious: dandelion leaves can be used in salad; its flowers are edible and can be used to make wine; and the roots can be roasted for a coffee substitute.

If, in the future, dandelion consumption were to become much more popular, then I see no reason why commercial breeding to produce larger leaves and bulkier roots shouldn't occur.

**Pat French**

*Rockhurst, Shropshire, UK*  
For the most part, if we haven't cultivated a plant for food,

there is probably a good reason.

If I take a sample of plants from a wild patch of my garden, there is a lot of grass, which we can't digest; a bit of ragwort, which is toxic; and some yarrow, which is safe enough in small doses. Nettle and white mustard can be eaten and contain useful minerals, but aren't very nutritious.

Many plants may be edible in that they (apparently) don't harm us, but they may not necessarily feed us. We have exploited the most nutritious plants from their wild ancestors. Perhaps we can do the same with others if there is sufficient need.

*[Ed. Before foraging for "weeds", be aware that many can be toxic, and nettles need to be cooked to remove the sting.]*

Why do some runners tie their hair in ponytails when this would surely create drag?

**Charles Merfield**

*Lincoln, New Zealand*

I have just published a paper on this very topic called "Redefining weeds for the post-herbicide era". In it, I argue that the term "weeds" is a value judgement and that there is no scientific means for determining if a plant is a weed.

I use the example of *Sonchus oleraceus*: Māori people in New Zealand call this *pūhā* and consider it a nutritious and tasty vegetable, but *pākehā* [the Māori term for New Zealanders of European descent] farmers call it sow thistle and consider it a weed.

So, at one level, the only thing stopping us eating "weeds" is our value judgements of them. At another level, many plants that are commonly called weeds – for example, chickweed (*Stellaria media*) and fat hen (*Chenopodium album*) – used to be eaten. In the case of fat hen, it fell out of favour when spinach was introduced to Europe. At the same time, a number of weeds are unpalatable or toxic, so you have to know your weeds before you eat any!

Another issue is ease of production. With deep irony for weed scientists, many weed seeds are notoriously difficult to reliably germinate due to dormancy, despite them germinating like, well, weeds in cultivated fields. All crops have had this dormancy bred out of them, so will germinate as soon as they are sown. Also, many weeds don't actually yield that much biomass compared with crops, so trying to grow them as a crop is uneconomical.

Finally, my proposed definition of weeds has the value judgement that weeds are "plants causing significant harm". So if a plant is being eaten, it isn't a weed, it is food. This definition makes the concept of edible weeds a contradiction. I therefore introduced the term *aliae plantae* to define all the plants that are neither crops nor "real weeds".



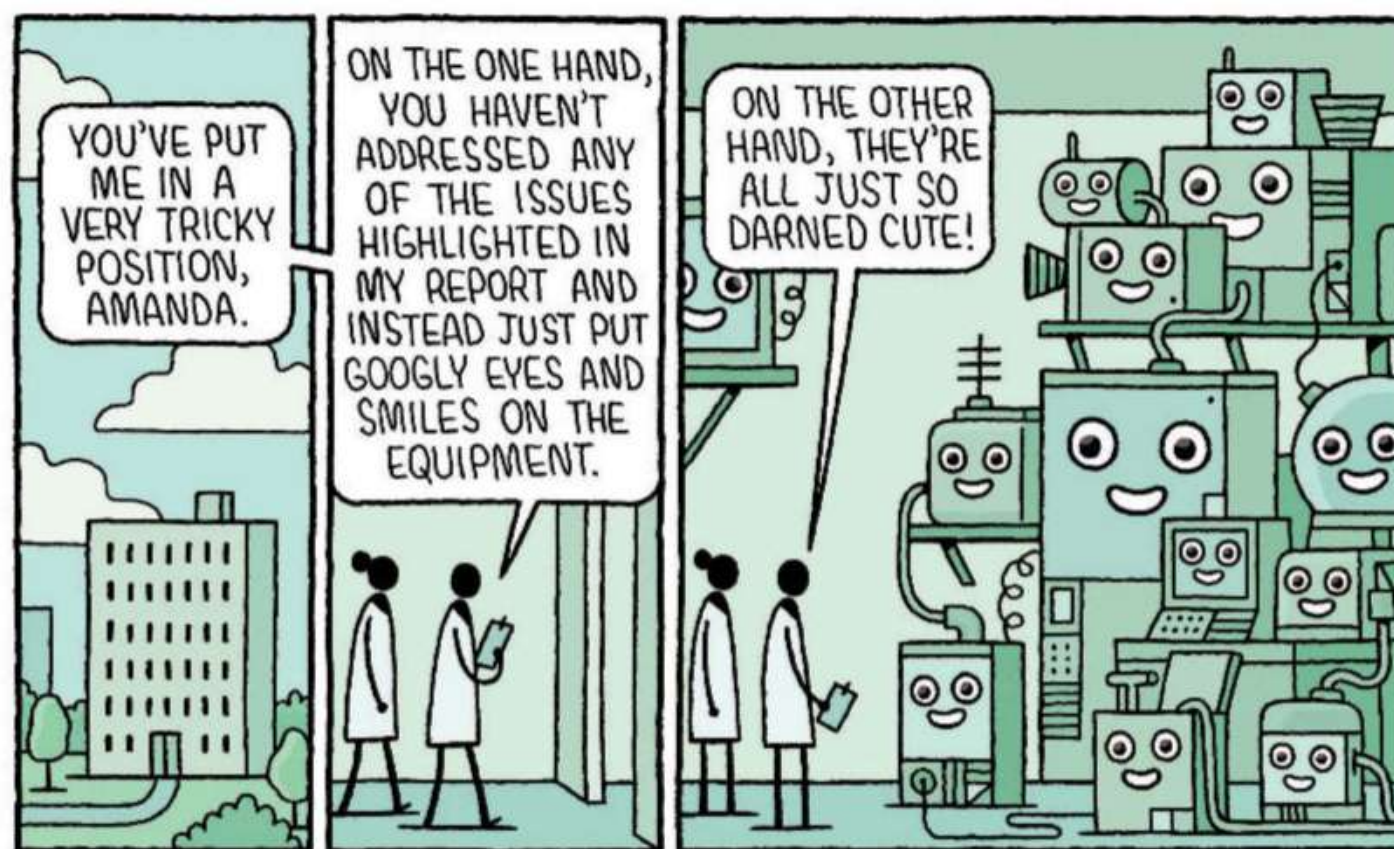
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**Tom Gauld**  
for *New Scientist*



## Original print

What determines fingerprints? Is it a random process or is it something inherited from our parents?

**Mike Follows**  
Sutton Coldfield,  
West Midlands, UK

Fingerprints begin to form in the 10th week of gestation. Some researchers think they are caused by tension between the outer layer of the skin (the epidermis) and the layer underneath it (the dermis), which results in tiny folds in the skin's surface.

An alternative hypothesis is that their formation might be the result of something called a Turing pattern, driven by biochemistry. Alan Turing is better known for breaking the Nazi Enigma code, but, in 1952, he explained animal patterning – how leopards get their spots and zebras get their stripes, for example. Each pattern is individual to each animal and the same mechanism might also explain why we all end up with unique fingerprints.

**“Unlike the rest of the family, my daughter has an incredibly rare fingerprint pattern, with eight arches and two unusual whorls”**

In Turing's “reaction-diffusion model”, molecules behave as either activators or inhibitors. The activator molecules replicate themselves, but produce inhibitor molecules at the same time.

A ridge in the skin forms when the concentration of activator molecules reaches a critical level. But the inhibitor molecules diffuse faster, so, once the concentration of the inhibitor exceeds that of the activator, the ridge comes to an end. The activator molecules act like fires spreading out from lots of different places simultaneously, while the inhibitor molecules behave like firefighters who outrun the fires to create firebreaks.

Despite following the same principle of formation, each

pattern is unique. This is because the places where the activator molecules reach a critical concentration are random.

Research published in the journal *Cell* earlier this year shows that genetics also plays a key role. This reveals that fingerprint patterns are genetically correlated with hand and finger proportions, and that the genes for limb development influence the patterns of whorls, arches and loops that characterise our fingerprints.

**Heather Riley**  
via Facebook

My father was a fingerprint expert, and was always being asked to look at our fingerprints to see if they had any special features.

From my grandparents down the generations, there were the usual loops and whorls and the occasional arch. Then you get to my daughter, who has eight arches and two unusual whorls.

My father told her: “That's incredibly rare, behave yourself!” ■

## Answers

### Quick quiz #166 Answers

- 1 Three
- 2 Mars and Jupiter – it is in the asteroid belt
- 3 Alfred Russel Wallace – it is known as Wallace's flying frog
- 4 1837
- 5 Egypt

### Cryptic crossword #90 Answers

**ACROSS** 1 Deep, 3 Matrices, 9 Webinar, 10 Field, 11 Cider, 12 Pot-herb, 13 Images, 15 Writhe, 18 Piranha, 20 Dosed, 22 Ether, 23 Sparrow, 25 Sapience, 26 JWST

**DOWN** 1 Dew, 2 Ebbed, 4 Abrupt, 5 Refit, 6 Clement, 7 Soda bread, 8 Untrue, 11 Crispness, 14 Airship, 16 Radial, 17 Parsec, 19 Nerve, 21 Straw, 24 Wit

### #181 A loss for words Solution

To score precisely 98 per cent with only one loss, Wendy must have lost on her 50th game, giving her a score of 49/50. After another 50 winning games, she will reach 99/100, precisely 99 per cent, but she needs a score of 99.5 per cent to round up to 100 per cent. 99.5 per cent is 199/200, so altogether she needs to win another 150 games in a row.

## Secrets of the ancients

We found ourselves completely lost. (Memo to self, don't read and walk.) It was news coming out of Bali that had proved so fatally distracting for Feedback ([newscientist.com/2333363](https://www.newscientist.com/2333363)). According to a paper in the journal *Ethology* by Camilla Cenni and her colleagues, the long-tailed macaques there have discovered how to use stone tools in "nonforaging contexts".

For those who need help interpreting this term: the macaques use them as sex toys and are furiously indulging in "behaviors of questionably adaptive value". Applying scientific language to this subject is a source of endless weak humour (see above), but the researchers get the last laugh. Who says stone tool use arose in humans because we were hunters, they ask?

## Time to upgrade

"You lost, mate?" Feedback gazed about. "Down 'ere." The mouse, in a cheap but smart striped suit and a little cap, had escaped from a lab, it turned out, having been subjected to various intelligence-enhancing rays and wavelengths.

"It all began," he explained, leading us to his little car, "with a study by researchers from Xi'an Jiaotong University in Shaanxi, China. They found that brief, low-dose radiation from terahertz waves increased the growth of mouse neurons by nearly 150 per cent in a Petri dish."

As the mouse opened the door of his cab for Feedback, he muttered, "'Course, soon every bleedin' rodent will be uplifted" – this because radio waves in the terahertz band can boost a smartphone's bandwidth to 1 terabit per second, making it a shoo-in for next-generation 6G communication technology.

Feedback was overjoyed, naturally: "Oh, brave new world! Oh, smarter, wiser creation! Imagine what people will be able to do with their expanded brains!"

The mouse adjusted his tiny rear-view mirror and caught our

## Twisteddoodles for New Scientist



### Got a story for Feedback?

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Consideration of items sent in the post will be delayed

eye. "What have people got to do with it?" he muttered. "Now, where d'you want to go?"

## Routemaster

Feedback was impressed to note that the mouse didn't use GPS, and an interesting discussion was had on the profound deskilling effect of geopositioning software on an animal, *Homo sapiens*, that already comes hardwired to figure directions out for itself.

Feedback brought up a *Scientific Reports* paper from 2020, in which Montreal researchers Louisa Dahmani and Véronique Bohbot put some startling numbers on the degree to which using GPS leaves the user clueless once the battery dies. They also remind us that unassisted wayfinding is infinitely richer even than map-reading, involving everything from wind

currents and snowdrift patterns to astronomical information.

Our driver was unimpressed. "Can't beat the whiskers," he preened, then had to swerve to avoid a four-legged snake. "Pedestrians," he snarled. By this point, Feedback needed a lie down.

## Reverse engineering

Not so the snakes. True, they long ago abandoned four-limbed locomotion. (A 2014 report revealed that their back legs evolved into a double penis, which raises the question, why would you not want to believe in evolution?) But now, it seems, they want their limbs back, at least according to a Serious Scientific Study by YouTuber Allen Pan.

"Nobody loves snakes enough to build them robot legs," he complains, in his latest video.

"Nobody except for me. Snake lover: Allen Pan." You can follow the evolution of his experimental prostheses on YouTube. No snakes were harmed, etc. On the contrary: they look to be having a high old time of it.

"Shouldn't be allowed on the road," our driver opined – which seemed a bit rich. Sensing Feedback's discomfort, he suggested we stop off for lunch.

## Rather hard on the owl

As Feedback contemplated the menu, our driver, who was something of a history buff, enthused about a huge new research programme being conducted at Cambridge University Library, which aims to digitise virtually everything we know about medieval medicine while cataloguing and conserving more than 180 manuscripts. "One treatment for gout," my friend explained, quoting project leader James Freeman, "proposes salting an owl and baking it until it can be ground into a powder, mixing it with boar's grease to make a salve."

## Harmonic resolution

At which point, possibly to drown out our conversation, the cafeteria's jukebox started to pelt out Janet Jackson's *Rhythm Nation*, a song that, according to a blog post by Microsoft developer Raymond Chen, contains one of the natural resonant frequencies for a model of legacy laptop hard drive, causing it to crash.

Given the strong physiological effects of certain frequencies, it was perhaps inevitable that the light in my companion's eyes should fade. Outside, the street was a sea of confused rodents. Meanwhile (for they had lost patience with the pedestrian lights), snakes were slithering from their prosthetic tubes and pursuing mice among the piles of little cars mounting up at each intersection. Feedback leaned back and sipped some tea, pleased normality was being restored. ■



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